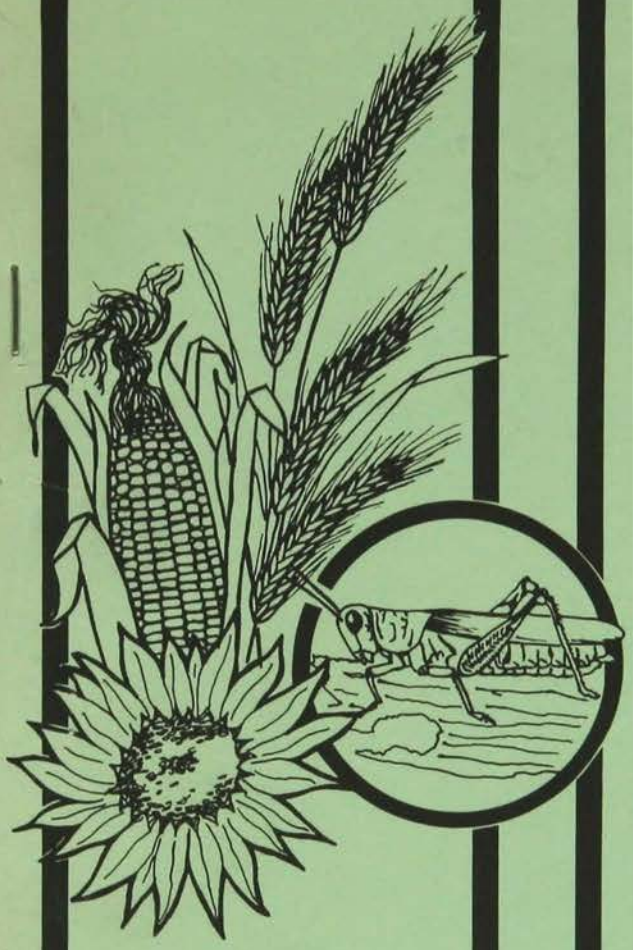

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Agricultural Extension Service
University of Minnesota

1983 Minnesota Pesticide Applicator Conference

Conducted by
Agricultural Extension Specialists
in Agronomy, Entomology, and
Plant Pathology

AGRICULTURAL EXTENSION SERVICE
and OFFICE OF SPECIAL PROGRAMS
UNIVERSITY OF MINNESOTA
COOPERATING WITH MINNESOTA
DEPARTMENT OF AGRICULTURE

PESTICIDE RECOMMENDATIONS

1983
Minnesota Pesticide Applicator Conference

Prepared by
Agricultural Extension Specialists
in Agronomy, Entomology, and Plant Pathology
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APHIDS ON SMALL GRAIN

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Four species of aphids are found to occur in small grains in Minnesota. These include greenbug (Schizaphis graminum), corn leaf aphid (Rhopalosiphum maidis), oat-birdcherry aphid (R. padi) and English grain aphid (Macrosiphum avenae). Economic aphid infestations in Minnesota small grain are normally initiated by weather frontal aided migrants from the southern states. As a result, mixed populations of two or more species are usually observed during our aphid years. Indeed, in 1982 all four species were common in heavily infested wheat, albeit in widely differing numbers. Greenbug tends to be the least commonly appearing aphid of the above four.

Aphids on small grain are capable of producing from 1 to 3 living young (ovoviparity) per individual per day. Such young are able themselves to begin to reproduce within a week. Optimal population increase tends to occur at lower temperatures (50-60^{o}F) during periods free of heavy weather. Lower temperatures apparently reduce predator and parasite effectiveness. Weather extremes, on the other hand, are detrimental to the aphids.

Aphid reproduction is not usually limited by the plant during the early stages of plant development until aphid numbers actually hurt the plant. And aphid numbers can decline dramatically, apparently due to plant maturity, as the plant enters the late boot and heading stages.

The fact that several good pieces of research demonstrate no yield effect from control of aphids from head emergence onward provides one clear point beyond which aphid control will not be profitable.

The question then becomes, what yield reduction can one expect from the numbers of the given aphid at the particular plant stage? Or more importantly when must one apply controls to prevent economic aphid injury to the plant?

Most research agrees that small grain injury/aphid is greatest with greenbug, next greatest with corn leaf aphid and least with oat-birdcherry aphid. English grain aphid appears not to injure the plant up to 100 or more per stem. In light of such injury differences, it is of some importance to know which aphid species are present and in what proportions. (A guide for aphid identification and a list of insecticides recommended for aphid control are discussed in Entomology Fact Sheet No. 43, Aphid Pests of Small Grain.)

Emphasis was placed on numbers of aphids per foot of row in our earlier discussions of action levels for aphids in small grain. These action levels, as you will see, were on the conservative side of more precise data generated recently by Kieckhefer et al. in South Dakota.

Kind of Aphid	Suggested Action Levels for Aphids in Small Grains in Numbers of Aphids per Stem		
	Seedling	Boot stage	Headed
Greenbug	15	25	Treatment
Corn leaf aphid	20	30	rarely
Oat-birdcherry aphid	20	30	pays
English grain aphid	30	50	

In making the decision of whether one should treat, it perhaps is most straightforward to count total aphids per stem. In no case should treatment take place at 15 aphids or less per stem irrespective of species of aphid, of plant stage, soil moisture conditions, presence of natural controls and/or crop value. Also one will rarely benefit from treating grain that is heading.

Adjustments in action level should be made, however, according to: 1) the aphid species complex as indicated, 2) soil moisture conditions, 3) abundance of predators and 4) value of the crop. In general a somewhat higher action level should be used where soil moisture is adequate, predators are abundant and the crop value is low.

SUNFLOWER DEFOLIATING AND SEED INSECT ACTION LEVELS

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SUNFLOWER DEFOLIATION

Excellent information (Table 1) is now available from hail injury tables relating defoliation to yield reduction in hybrid sunflower. Data relating insect numbers to percent defoliation and to yield reduction are much less available. However, some rules-of-thumb action levels based on defoliating insect numbers will permit control judgments before economic injury thresholds are exceeded.

Table 1. Percent yield reduction vs percent defoliation at following plant stages.

Percent defoliation	Percent yield reduction for defoliation at given plant stage			
	2-14 leaf	15-32 leaf	Early to late bud	Bloom complete
25	0	0	10	0
50	5	15*	25*	12*
75	10*	22*	50*	20*

*Significantly different from untreated check.

With sunflower beetle each larva contributes about 1½% defoliation. Thus 25% defoliation of one plant would be equaled by the completed feeding of approximately 17 larvae. Certainly a grower would be justified to treat fields with 20 sunflower beetle larva/plant. A thistle caterpillar will contribute between 3 and 5% defoliation so that fields with between 5 and 7 thistle caterpillars per plant normally would require treatment.

Occasionally the normal phenology of the plant and insect pest are displaced temporally. In such cases the more correct way to make control judgments is base control on defoliation and not on insect numbers.

An abundance of sunflower beetle in 1982 permitted comparisons of several potential substitutes for toxaphene. Both yields and percent larval control were collected but yields have not been analyzed. Of the compounds compared Supracide, Toxaphene and Sevin are presently labeled. Pydrin, Ambush, Cymbush, Pay-Off and Ammo are synthetic pyrethroids, a group of insecticides with unusual biological activity.

In Table 2 all compounds at all rates performed exceedingly well. A second trial (Table 3) employing reduced rates for candidate compounds again showed excellent control by most materials. All plots were replicated four times.

Table 2. Larval sunflower beetle control - Minnesota 1982. Dave Noetzel and Lisa Behnken. (Preliminary data)

Insecticide	Rate ai/A	Percent control
Supracide	0.5	100
Ambush	0.1	100
Pydrin	0.1	100
Pydrin	0.05	100
Cymbush	0.04	100
Cymbush	0.02	100
Pay-Off	0.04	100
Pay-Off	0.02	100
Pay-Off	0.01	100
Ammo	0.02	100
Toxaphene	1.0	99
Penncap M	0.5	98
Sevin XLR	1.0	89
Penncap M	0.25	88
Check	-	0

Treated in the evening
Total material = 25 gallons/A
Counts 7 days after treatment; initial population 17 larvae per plant

Table 3. Larval sunflower beetle control - Minnesota 1982. Dave Noetzel and Ken Pazdernak. (Preliminary data)

Insecticide	Rate ai/A	Percent control
Pydrin	0.05	100
Pydrin	0.025	100
Ammo	0.01	99.6
Ambush	0.05	99.6
Ambush	0.025	98.8
Cymbush	0.01	98.4
Pay-Off	0.005	97.6
Ammo	0.005	96.4
Toxaphene	1.0	96.4
Supracide	0.25	93.2
Check	-	0

Treated in early evening
Total material = 25 gallons/A
Counts 24 hours after treatment; initial population 13 (3rd and 4th instar) larvae/plant

SUNFLOWER SEED INSECT ACTION LEVELS

Insects which infest the florets of sunflower include sunflower midge, sunflower moth, banded sunflower moth and seed weevils.

SUNFLOWER MIDGE

Following work in 1981 which clearly confirmed differential sunflower hybrid response to moderate and light midge infestations the question of insecticide control of midge appeared still to be confusing. Thus a trial (Table 4) was initiated at Morris under the direction of Dr. Dennis Warnes.

Four replicates of four planting dates with ½ of each plot treated with 0.2 lb. Ambush per acre every four days starting before midge eggs hatched and until midge activity ceased produced the following results. A total of six insecticide applications were applied to half of each plot for each of the first two dates of planting.

Table 4. Sunflower midge control. Morris 1982. Noetzel and Warnes. (Preliminary data)

Hybrid	Damage rating					
	Planted 5/21		Planted 5/27		Planted 6/4	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
NK 212	2.0*	3.0	1.5	2.6	.3	.6
IS 894	.3	.5	.9	1.3	.1	.3
St 315	.1	.3	.9	.9	+	.1

Damage rating scale 0 to 4 where 4 is 75% or more damage and/or cupping.

The results confirm the hybrid difference in midge response observed in 1981. Date of planting does have a relationship to midge injury. It appears equally clear that even a spraying regime that far exceeds the practical possibilities for control is almost totally ineffective.

Special thanks are expressed to Northrup King, Interstate Seed, and Seed Tec for providing seed for this trial. We particularly appreciate the use of NK 212 which is an outstanding indicator plant for the sunflower midge.

SUNFLOWER MOTH

Adults which initiate economic infestations in this area are blown along weather frontals from southern states. Eggs and early instar larvae (dark colored with narrow white longitudinal stripes) are nearly impossible to monitor so control actions must be based on adult counts.

Canadian workers isolated a pheromone with which they were able to collect adult male moths shortly after they arrived in Canada. This pheromone is now available from Albany International, Controlled Release Division, 110 A Street, Needham Heights, MA 02194. Although we have not had an economic infestation in recent years, the traps are effective.

We have no additional data with which to question the two adult moths per five sunflower plants as an action level. However, fields which are beginning to bloom at the time the migrant adult arrives will not suffer economic injury. Likewise fields which are more than 14 days away from bloom will also escape injury.

BANDED SUNFLOWER MOTH

The Crop Pest Management program permitted us to pull pre-harvest samples from nearly 80 fields in 1980 and about 40 fields in 1981. We dried these samples, removed a random sample from each plot prior to cleaning the samples and then measured seed weevil and banded moth injury in the monitored fields. In 1980 we did not have any insecticide treated fields. In 1981 there were about 15% treated. However, these were not separated for this study.

As you can see in Tables 5 and 6 it would appear that we are probably over-estimating the seed weevil problem and greatly underestimating banded sunflower moth damage.

The average percent reduction per seed agrees very well with Oseto's data from North Dakota. A difficulty, however, is the small seeded hybrids have a much greater % reduction in seed weight per seed. This amounts to nearly 100% difference in economic threshold if calculated from a percent weight loss per seed.

The two years data are quite consistent and are presented because of the threshold question for seed weevil control and because banded sunflower moth is a much greater problem than any of us thought.

It's my feeling that banded sunflower moth may have been the number one problem in sunflower in Minnesota in 1982 and certainly was no worse than second to midge.

Table 5. Effect of seed weevil and banded sunflower moth on seed weight reduction per seed and yield reduction. 77 West Central Minnesota CPM fields. 1980. (Noetzel & Sederstrom)

Insect	Percent reduction in seed weight/seed			Percent fields showing following % yield reduction			
	Lowest	Average	Highest	0	1-9	10-19	20 →
Seed weevil	12*	35	68	7	93		
Banded moth	16	54	100	15	76	9	
Combined	-	-	-	0	82	13	4

* This value represents a value for a hybrid or field and is based on a 200 seed sample from 3 commingled (75 row feet) pre-combine samples. Damage was counted before the material was cleaned.

Table 6. Effect of seed weevil and banded sunflower moth on seed weight reduction per seed and yield reduction. 38 West Central Minnesota CPM fields. 1981. (Noetzel & Sederstrom)

Insect	Percent reduction in seed weight/seed			Percent fields showing following % yield reduction			
	Lowest	Average	Highest	0	1-9	10-19	20 →
Seed weevil	7*	34	65	4	89	7	
Banded moth	18	56	100	7	75	12	6
Combined	-	-	-	0	71	18	11

* This value represents a value for a hybrid or field and is based on a 200 seed sample from 3 commingled (75 row feet) pre-combine samples. Damage was counted before the material was cleaned.

We have several trials of banded sunflower moth control over the years and have included one from the Lamberton experiment station for this report (Table 7). We have been interested in effect of different insecticides on pollinators and pests in a high and a low autogamous hybrid. No differences in this pollination aspect are apparent, but we can compare efficacy of the insecticides used against, in this case, banded sunflower moth. All of the compounds at the rates tested appear to provide acceptable banded sunflower moth control.

Table 7. Banded sunflower moth control. Lamberton 1981. (Ford & Noetzel)

Insecticide	Rate* ai/A	Infested seeds per 200	Percent reduction
Supracide	0.5	2.4	86
Penncap M	1.0	2.6	85
Pounce	0.1	3.6	79
Pydrin	0.1	3.6	79
Ambush	0.1	4.2	75
Untreated	-	17.0	-

* Two applications at this rate 7 days apart. First application at 10-20% bloom.

At the present time there is no foolproof monitoring system for this insect. A pheromone trap is being researched but is not presently available. We have collected adults from sunflower moth pheromone traps, but we are unsure that the banded moth male is responding to that chemical. We have determined economic infestations (10% or more yield reduction) to have occurred in fields which were regularly visually monitored and in which we failed to see adults.

We almost feel that if one observes moderate banded moth activity in field margins, field treatment will benefit the grower. Growers in areas which routinely treat for seed weevil will not need to pay as much attention to banded sunflower moth as those who do not. Excellent banded moth larval control is being obtained with the insecticides and timing used for seed weevil control.

We are currently unsure that treating field borders and grassed waterways are sufficient to handle economic levels of banded moth. The two times we have attempted this control measure it has failed miserably.

SUNFLOWER SEED WEEVIL

There is general concensus that yield is reduced 0.006 (or 0.6%) per seed weevil adult based on Oseto's study which indicated 20 seeds are infested for each weevil counted. We have generated information which shows considerable difference in the % of a single kernel consumed by a larva, but final yields do not show a proportionate yield effect. The minor disagreement about adult counts used for action levels is caused by slightly different interpretation of control experiment data.

Statistical variation in yield data is usually so great in sunflower that yield differences of something around 200 lbs per acre are required to be significant at the 5% level. However, if one calculates actual yield reduction per acre with one weevil per plant, it turns out to be 12 lbs. Yield reduction for 10 weevils per plant would justify control costs if such differences were statistically significant.

We have tended downward on our action levels for sunflower seed weevil control and would tend to agree that control at about 10-15 weevils per plant in oil hybrids will pay. Confection hybrids require weevil control at perhaps 2 adults/plant. (The movement of confection production out of weevil and banded moth area was indeed wise.)

To count adult weevils it is very simple if a repellent, such as Off, or a pyrethrin aerosol is sprayed lightly over the head. Be sure the counts are made in several sections of the field.

The second "disagreement" in seed weevil control has to do with timing the insecticide application. Again there is agreement that the optimum timing for control lies between 3/10 plants in bloom (30% bloom) and 10/10 plants in bloom (100% bloom). The data we have collected would suggest that insecticide efficacy peaks at about 80% bloom (8 of 10 plants with male flowers). However, we have experiments where controls were applied at 30% bloom and percent control equaled the best control we have achieved. We have also had failures with early treatment.

To summarize then it will probably pay the grower to control seed weevil in oil hybrid sunflower at approximately 10-15 adult weevils per plant. Controls should be applied somewhere between 30% and 80% bloom (where bloom is more or less uniform). If adult weevil populations are marginal (i.e., 10-20 per plant), it will be best to wait until 80% bloom or so to treat.

STATUS OF TOXAPHENE

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On October 17 the EPA announced the proposed cancellation of all but selected uses of Toxaphene. Registrants had thirty days in which to reply to the proposed cancellation. All indications were (and are) that the cancellations will not be protested.

In the proposed cancellation it stated that products in manufacturers' hands (this appears to include distributors) would have to be re-labelled for permitted uses. Henceforth the permitted products would be Restricted Use. Permitted uses included scabies control on sheep and non-dairy animals, 24(C) use for sickle-pod control in soybean, peanuts and no-till corn, and special emergency use (Sec 18's) for cutworm, armyworm and grasshoppers in cotton, corn and small grain. These uses will continue only until 1986.

We are unable to obtain a legal opinion on whether toxaphene in growers' or applicators' hands can be used. However, the opinion was offered that since the order did not specifically speak to this disposition, the material could be used.

All suggested uses of toxaphene have been removed from the 1983 Minnesota recommendations. If the final order should alter the need for this, we will make news releases to extension agents and dealers. The cancellation will not leave very many insecticide gaps to fill in Minnesota. In fact, replacements in many cases have superior performance for the toxaphene uses previously recommended.

Insecticides Currently Registered In Minnesota

For Insects Infesting Stored:

I. GRAIN (Corn, Oats, Barley, Wheat, Rye)

A. Storage Facilities -

1. Residuals -- Malathion, Methoxychlor, Pyrethrin

2. Fumigants -- Chloropicrin

B. Product -

1. Residuals -- Malathion, Pyrethrin, Dipel (BT)

2. Vapor Toxicants -- Dichlorvos

3. Fumigants --

a. Liquids - carbon tetrachloride, carbon disulfide, ethylene dichloride, ethylene dibromide, sulfur dioxide, chloropicrin and chloroform

b. Solids - Phosphine (Fumitoxin, Phostoxin, Gastoxin, Degesch)

c. Gas - Methyl bromide

II. SOYBEANS

A. Product -

1. Residuals -- Dipel (BT)

2. Vapor Toxicant -- Diclorvos

3. Fumigant -- Phosphine (Fumitoxin, Phostoxin, Gastoxin, Degesch)

III. SUNFLOWERS

A. Product --

1. Residuals -- Dipel (BT), Malathion (label approval anticipated in 1983)

2. Vapor Toxicants -- Dichlorvos

3. Fumigants -- Phosphine (Fumatoxin, Phostoxin, Gastoxin, Degesch)

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

Preventing Stored-Grain Insect Infestation

ENTOMOLOGY FACT SHEET No. 9
Revised 1983
PHILLIP K. HAREIN

Minnesota grain is generally safe from infestation by stored-grain insects before harvest. This is not true for grain in many of the southern states. The only exception in Minnesota may be where grain is cut and swathed adjacent to storage bins being treated with an insecticide (including fumigants) in preparation for the new crop. Stored-grain insects will migrate away from treated bins for short periods of time.

A survey of stored corn and wheat on Minnesota farms in 1977-1980 revealed the presence of many insect species that feed on moldy grain. These included the flat grain beetle, the rusty grain beetle, and the foreign grain beetle. Other species noted were the sawtoothed grain beetle, the red flour beetle, the confused flour beetle, and the Indianmeal moth.

Many species of stored-grain insects develop through their worm stage (eggs and pupal stage also for some species) within kernels of grain. These are usually weevils or the lesser grain borer. Other insect pests do not develop within kernels. However, they will feed into the germ and advance later into the endosperm. They prefer broken kernels, but will feed also on sound whole kernels.

Accumulations of postharvest grain are primary targets for insect infestations, especially if stored with or adjacent to old grain. The initial site where this postharvest infestation can begin is within the harvesting machinery. Unfortunately, this equipment is not designed to remove old grain from last year's harvest. The same applies to grain augers and elevators and the subfloors or aeration ducts in most storage bins.

Although stored-grain insects can be killed by various chemical and nonchemical methods, thorough sanitation (with the use of insecticides as a supplement rather than as a substitute for sanitation) is the most effective procedure for preventing insect infestations.

Conditions That Encourage Stored-Grain Insects

Temperature, moisture, and grain dockage or broken kernels interact providing adequate (if not optimum) conditions for stored-grain insect reproduction and survival. The most favorable grain temperature for these insects is about 80° F. At temperatures above 90° F or below 60° F, reproduction is nil and survival time is reduced.

The most favorable moisture range for stored-grain insects is 12% to 18%. Insects that feed on mold prefer the higher moisture levels. However, as temperatures increase, insects can reproduce in grain with relatively low moisture content, and when moisture increases, they can reproduce at relatively low temperatures.

Insect infestations differ in clean vs. dirty grain. Dockage will directly influence the preference in subsequent insect infestation of grain. This is the primary reason insects often accumulate in spout line areas.

Unfortunately over-filling bins is a common practice in Minnesota which results in inadequate space to inspect or treat the grain. Uneven grain surfaces also contribute to nonuniform air flow during aeration. Level the grain, after binning is complete, at least six inches below the top of the bin wall. Or, immediately following harvest, level the grain to the proper height in an over-filled bin by removing enough grain from the bottom of the spoutline area. This grain will contain a relatively high percentage of broken kernels and foreign matter. Feed it to livestock, screen it before rebinning, or sell it.

Inspect grain at 7- to 30-day intervals, depending on the potential for increased insect infestations. Check for insects by screening them from the grain, examining kernels for damage, looking for webbing, detecting off-odors, or determining grain temperatures. The temperature could be as high as 110° F due to the insect activity. During the summer and fall, insect infestations are usually near the surface of the grain. During cold weather these insects will congregate at the center of the grain mass.

Preventing Infestation of Stored-Grain Insects

SPRAYING FACILITIES

Thoroughly clean combines, trucks, wagon beds, conveyors, elevators, and bins. Spray the surfaces of the equipment that will be in contact with the grain, using one of the following insecticides at least two weeks before harvest.

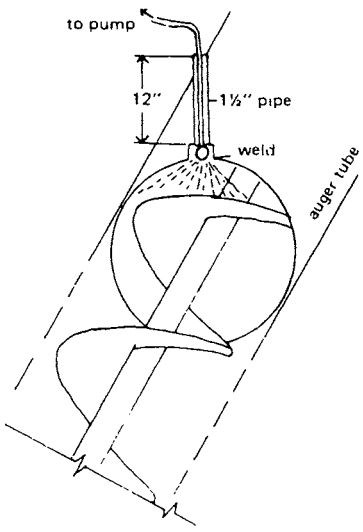
Insecticides	Amount of insecticide mixed with water
methoxychlor 50% W.P.	1 lb/2.5 gallons
methoxychlor 25% E.C.	1 qt/2.5 gallons
malathion-premium grade 50 to 57% E.C.	1 pt/3 gallons

W.P. = wettable powder
E.C. = emulsifiable concentrate

Spray to the point of run-off, using 1 gallon of total formulation, containing one of the insecticides listed above, per 500 square feet of surface. A 2- or 3-gallon compressed air garden sprayer should be adequate for applying these insecticides. Also spray the outside walls of the bins to a height of six feet and the ground to a distance of six feet out from the foundation of each bin. Wettable powder suspensions must be agitated frequently in the sprayer during application, to insure uniform dosages. Mix only one days' supply of these formulations, as they lose their effectiveness in contact with water overnight.

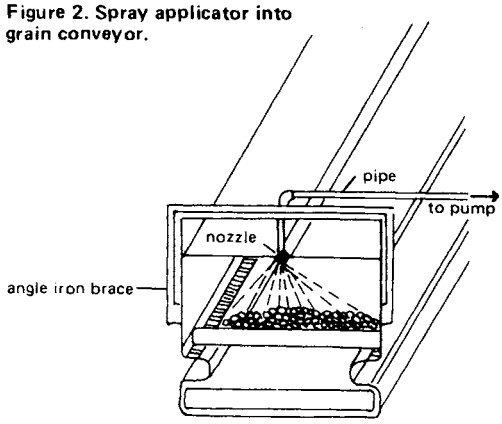
It is not recommended that new grain be mixed with old grain in storage. However, if it is not possible to remove the old grain before harvest, check it carefully for stored-grain insects and, if needed, treat it with recommended residual insecticides or fumigants before adding new grain.

Figure 1. Spray applicator into grain auger.



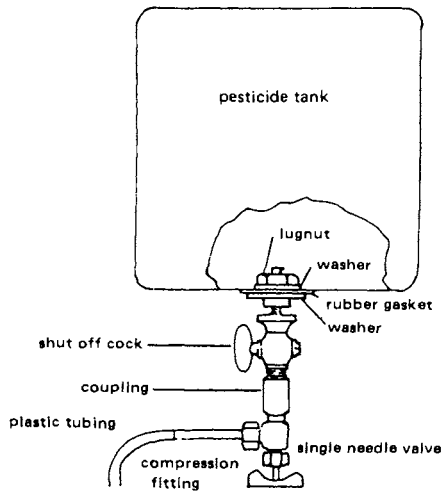
NOTE: Clamp nozzle inside approximately 12" length of 1½" pipe. Be sure pipe is large enough to observe spray pattern. Place nozzle near intake end of auger tube, but above grain level in hopper.

Figure 2. Spray applicator into grain conveyor.



NOTE: For convenience, locate spray nozzle near hopper end of conveyor. Adjust nozzle height to give coverage across entire width of conveyor.
(From University of Georgia College of Agriculture. "Protect Stored Grain From Insect Damage" by John French.)

Figure 3. Drip-on applicator.



(From Jim Quinlan, USDA, Manhattan, Kansas.)

Grain Protectants

Insect infestation is prevented or reduced by treating small grain and shelled corn as they are moved into storage. Use one of the approved insecticide formulations described below:

malathion - 1 pint 50% to 57% premium-grade E.C. per 2 to 5 gallons water per 1,000 bushels.

malathion - 1% premium-grade in wheat flour dust, 60 pounds per 1,000 bushels (also available in 2, 4, and 6% dust formulations).

Malathion is registered for use directly on stored barley, corn, oats, rye, sorghum, and wheat. It cannot be applied to stored soybeans. Grain can be fed or sold anytime after treating. The protection provided by malathion is reduced to a few weeks if the treated grain is warm and has a high moisture level. Malathion on cool dry grain should be effective for three to six months.

Protectants are formulated as dusts or liquids. Dusts can be added to the grain stream as it is elevated or conveyed into the bin. Liquids can be applied adequately as a spray (see figures 1 and 2) or with "drip-on" applicator (see figure 3).

A simple "drip-on" applicator for metering liquid formulations is adequate. To build the applicator, fit two brass plumbing valves and polyethylene tubing in sequence to an opening in the bottom of a container to hold the insecticide formulations. This container is suspended over the top of the auger or conveyor with the end of the tubing positioned so the insecticide can drip directly into the grain. A shut-off cock on the container serves as an on-off valve, while a needle valve regulates the amount of insecticide applied. The needle valve is calibrated to the desired flow for the amount of grain being delivered into storage. Two hundred bushels can be treated at the five gallon per 1,000 bushel rate with 3.2 ounces of 57% malathion emulsifiable concentrate mixed with one gallon of water.

Surface Grain Treatments

Suggested rates for the surface treatment of filled grain bins are:

malathion - ½ pint 50% to 57% premium-grade E.C. in 2 gallons of water per 1,000 square feet of grain surface area.

malathion - 1% premium-grade in wheat flour dust, 30 pounds per 1,000 square feet.

Apply the spray evenly over the surface, immediately after the grain is loaded into storage and leveled off. This "topping off" treatment helps prevent insects from infesting the grain on the surface.

If the grain is to be stored for long periods, it is necessary to have adequate drying and aeration equipment to maintain grain temperature and moisture control. However, malathion should not be applied to the grain until it is dried adequately. Drying and aeration should be considered part of an integrated insect management program with the malathion treatments.

Information Source

For details on aeration equipment for grain temperature control, refer to the University of Minnesota Agricultural Extension Service publication M-165, *Management of Stored Grain With Aeration.*

A current list of approved residual insecticides for use in empty bins and directly on the grain is available from the Minnesota Department of Agriculture, 90 West Plato Blvd., St. Paul, MN 55107 or Mr. Ron Gardner, University of Minnesota, 228 Hodson Hall, St. Paul, MN 55108.

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AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

ENTOMOLOGY FACT SHEET No. 50
Revised 1983
PHILLIP K. HAREIN

Fumigating Stored Grain

Stored grain should not require fumigation in Minnesota, especially if adequate provision is made to prevent insect infestations by proper sanitation and the use of residual insecticides (see Entomology Fact Sheet No. 9, *Preventing Stored Grain Insect Infestation*). Moving or aerating grain, especially when air temperatures are low enough to reduce grain temperatures to 60° F or lower, will reduce insect activity. Malathion can be applied as a residual insecticide to supplement a stored-grain insect pest prevention program. A fumigation may be justified if the insect prevention efforts fail.

Fumigants can be applied as solids, liquids, or gases but they all must be in the gaseous state to penetrate grain and kill the insects. They have no long-term effectiveness; as soon as they diffuse away from the target area, insect reinfestation can follow immediately.

It often is safer, less expensive, and more effective to have your stored grain fumigated by a licensed and certified professional fumigator than to do it yourself. This applies especially to single bins containing more than 5,000 bushels. Flat storage structures are usually more difficult to fumigate satisfactorily than upright bins because of the relatively large grain surface area in flat storages. This is an area where insects congregate and fumigants dissipate quickly to ineffective concentrations.

There are several reasons to consider hiring a professional fumigator to conduct your fumigations. The most important reason is your personal risk in handling a highly toxic pesticide. A professional fumigator will: (1) have both the knowledge and experience in fumigating, (2) have the special equipment required to apply fumigants, and (3) be aware of safety devices (such as gas masks) which can prevent overexposure.

The grain fumigant application method most often used on Minnesota farms involves pouring liquid-type fumigants onto the surface of the grain mass. Recommended dosages usually range from 2 gal to 5 gal per 1,000 bu of grain. Thus, in a 20,000 bu bin this would require a minimum application of 40 gal of fumigant. Most Minnesota farmers would apply these liquid fumigants by inverting a sufficient number of 1 gal or 5 gal containers of the fumigant into the grain surface. The time required for such an application to a grain mass of over 5,000 bu could be excessive for the applicator, especially if the correct type of gas mask were not being worn properly. Two people should always work together when fumigating. Both need adequate safety equipment. During the fumigation adequate warning signs must also be posted on grain bins and then removed when the fumigant has been released. However, grain fumigants can be used satisfactorily if the necessary safety measures are followed and the major factors (listed below) that alter the effectiveness of a fumigation are understood

Temperature

Grain temperature is extremely important, as it controls the speed of fumigant vaporization and penetration of the gas through the grain. Low grain temperatures (less than 50° F) significantly slow down the movement of the gas. Insect respiration is also reduced at temperatures below 50° F, resulting in reduced kill. Extended fumigation periods may be needed. The adjustment for grain temperature is often given on the label.

Moisture

High-moisture grain retards the movement of the fumigant and may result in increased absorption into the grain kernels, resulting in reduced gas concentrations and higher residues.

Bin Construction

A fumigant must be held in the grain long enough and at sufficient concentrations to kill insects. Tightly sealed metal or concrete structures are required for some fumigants. Carefully caulked wooden bins can be used. Covers of polyethylene or plastic-coated nylon will be helpful to assure effective fumigation in any grain storage facility.

Depth of Grain

The shape and depth of grain in the bin also affects the fumigant. Upright bins present a minimum of grain surface for the loss of the gas. Whenever possible, a gas-tight cover should be used over grain in flat storages or when a bin is only partially filled.

Ventilation

Most fumigants are heavier than air and sink through the grain. Penetration through the entire grain mass, especially in deep bins, can be assisted by using aeration. Remember to seal off the aeration system during the actual fumigation. Aeration also can be used to remove the fumigant, following the recommended exposure period.

Dockage

Dockage in grain presents another variable affecting the efficiency of a fumigant. The sorptive capacity of grain will increase with increases in dockage. As grain is loaded into bins, the light dockage (chaft, dust, etc.) settles around the outside of the grain mass while heavier dockage settles or is trapped near the center. This uneven distribution of dockage causes fumigants to channel through grain by flowing through areas of least resistance. Insects congregate in areas of high dockage and may escape lethal gas concentrations.

Fumigant and Dosage

Although fumigant formulations vary in their efficiency, this variable is usually of less importance than the variables listed above. Regardless of which fumigant you select, you should always follow recommended dosages. Less than maximum labeled dosages may require refumigation. Excessive dosages are wasteful and can initiate unnecessary hazards.

Fumigation Guidelines

Effective fumigations result from following several recommended guidelines such as the following:

- Level the grain. Remove or break up any crust on the surface.
- Seal all cracks, making the bin as airtight as possible.
- Fumigate when the *grain* temperature is between 70° and 90° F.
- Keep the bin closed for at least 72 hours after applying the fumigant.
- DO NOT ENTER the bin during or after fumigation until gases have been removed by aeration.

Fumigant Characteristics

Basic characteristics of some of the most common fumigants used for stored-grain insects in Minnesota are listed below.

Type	*Characteristics*
Liquid grain fumigants:	
Tetrafume Tetrakill Dowfume 75 Vertifume Weevil-Cide	Liquid formulation usually containing various percentages of carbon tetrachloride, carbon disulfide, ethylene dibromide and ethylene dichloride. Pungent odors are common.
Larvacide	Liquid formulation of chloropicrin. Good penetrator. Low concentrations irritate eyes.
Solid grain fumigants:	
Phostoxin Fumitoxin Gastoxin	Solid formulations that release phosphine. Carbide-like odor. Relatively easy to apply. Excellent penetrator.

Phosphine Formulations

Phosphine is applied to grain from various solid formulations. It can be applied to grain by prorating the tablets, pellets, or packets of powder in the grain as it flows into storage, or by injecting the tablets or pellets into binned stored grain using a special metal probe. The procedure calls for pushing the probe into the grain mass and then applying the solid formulation through the center of the tube as it is withdrawn. The phosphine formulations may also be applied to layers of grain in the bin during loading to aid in the distribution of phosphine. However, since the phosphine gas is usually released within 2 hrs after the formulation is applied to the grain, it should be covered with plastic following each phosphine application if the bin is not going to be filled within 2 hrs.

Selecting a Fumigant

The selection of fumigants for your particular need may be difficult. They vary in their chemical, physical, and biological factors. As a guideline, an ideal fumigant should have most of the following properties:

1. low in cost per effective fumigation;
2. highly and acutely toxic to all developmental stages of the target insects;
3. highly volatile with good penetration power (but not be excessively sorbed by grain);
4. easily detected, with adequate warning properties;
5. noncorrosive, nonflammable, and nonexplosive under practical conditions, with good storage life;
6. nonreactive with the commodity so as not to produce adverse odors or flavors;
7. able to aerate readily, leaving no harmful residues;
8. noninjurious to seed germination and not detrimental to the commercial grain grade;
9. nondamaging to milling qualities or other processing properties of grain;
10. readily available and simple to apply.

Information Source

A current list of approved residual insecticides for use in empty bins and directly on the grain is available from the Minnesota Department of Agriculture, 90 West Plato Blvd., St. Paul, MN 55107 or Mr. Ron Gardner, University of Minnesota, 228 Hodson Hall, St. Paul, MN 55108.

CAUTION

All insecticides must be handled with respect. Read and follow directions and precautions on the container labels. Avoid contaminating the skin and clothing. Do not breathe the dust or spray. After applying insecticides change clothes and wash thoroughly with soap and water. Store pesticides in a safe place where children and pets can't obtain them. Dispose of empty containers safely.

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1982 CORN ROOTWORM INSECTICIDE TRIALS
WASECA

TREATMENT	AVERAGE ROOT RATING (1-6)	AVERAGE YIELD BU/A
COUNTER 15G	2.30	165
THIMET 20G	2.75	149
DYFONATE 20G	2.80	156
MOCAP 15G	2.90	159
MOCAP 20G	2.95	162
CHECK	3.05	152
LORSBAN 15G	3.30	170
AMAZE 20G	3.50	162
FURADAN 15G	3.65	159

1982 CORN ROOTWORM INSECTICIDE TRIALS
MORRIS

TREATMENT	AVERAGE ROOT RATING (1-6)	% PLANTS "GOOSENECKED"
COUNTER 15G	2.25	5.2
THIMET 20G	2.70	4.5
AMAZE 20G	2.80	4.5
MOCAP 15G	3.10	12.8
MOCAP 20G	3.20	14.5
FURADAN 15G	3.20	15.2
DYFONATE 20G	3.80	11.2
LORSBAN 15G	3.90	14.5
CHECK	5.10	56.5

1982 CORN ROOTWORM INSECTICIDE TRIALS
JANESVILLE

TREATMENT	AVERAGE ROOT RATING (1-6)
COUNTER 15G	2.20
AMAZE 20G	2.60
FURADAN 15G	2.65
LORSBAN 15G	2.95
CHECK	3.10
DYFONATE 20G	3.25
THIMET 20G	3.45
MOCAP 15G	3.55

MINNESOTA CORN ROOTWORM ADULT SURVEY 1982

DISTRICT	NO. COUNTIES	NO. FIELDS CORN/CORN	NO. BEETLES/ACRE 1981	1982	RATIO NORTHERN:WESTERN
WC	6	26	32,333	11,625	99: 1
C	5	21	27,828	11,489	100: 0
EC	5	20	3,860	5,936	99: 1
SW	5	25	52,162	29,329	88:12
SC	5	22	24,141	18,671	97: 3
SE	5	16	24,253	36,920	80:20
	31	130			
STATEWIDE AVERAGE			27,429	18,995	94: 6

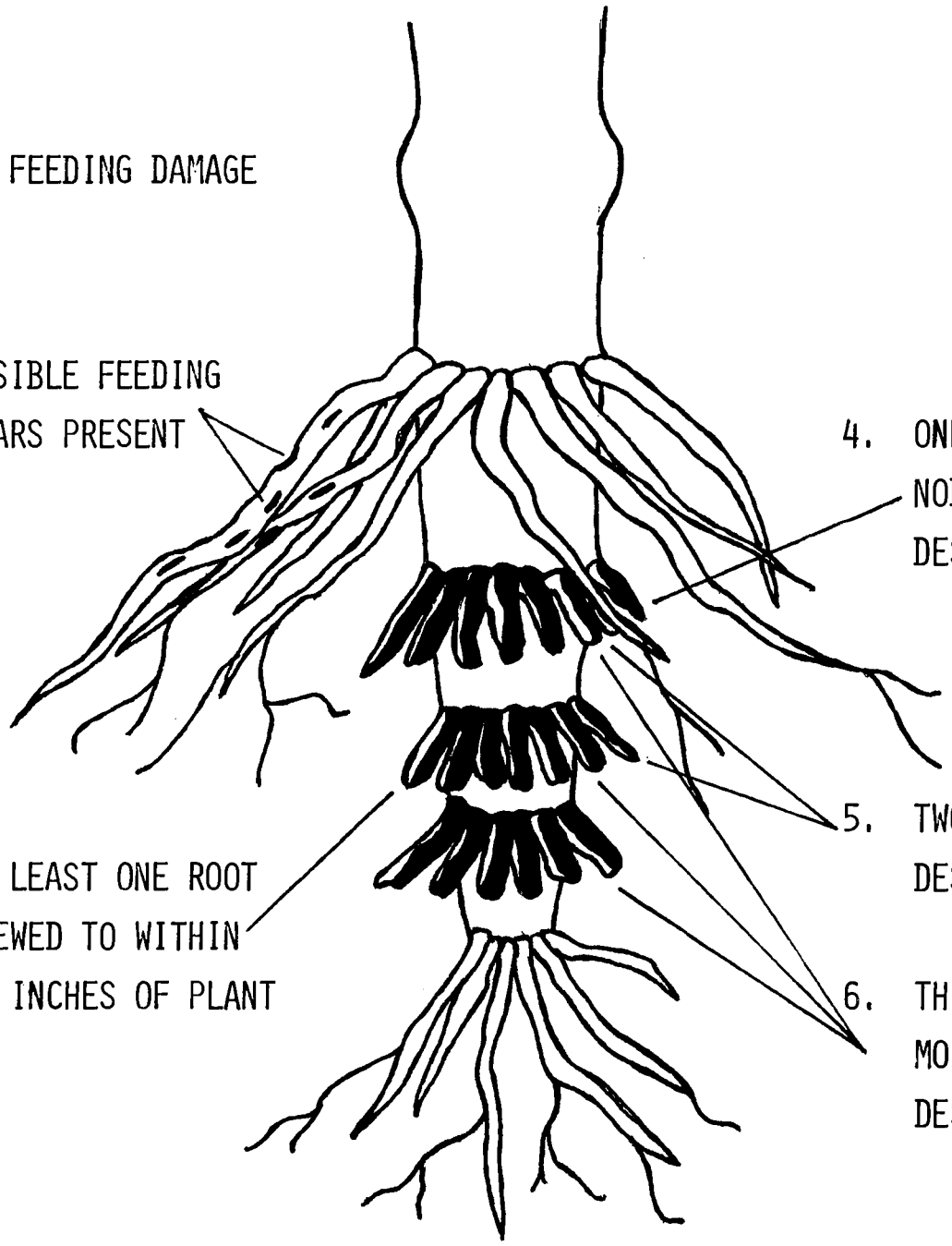
MINNESOTA EUROPEAN CORN BORER FALL SURVEY 1982

DISTRICT	NO. COUNTIES	% PLANTS INFESTED	NO. BORERS/100 PLANTS 1981	1982
WC	5	45	22	65
C	6	32	44	31
EC	5	17	18	13
SW	5	44	25	48
SC	5	41	28	47
SE	5	22	29	11
STATEWIDE	31	33	28	36

From the Division of Plant Industry, Minnesota Department of Agriculture.

ROOTWORM DAMAGE RATING

IOWA 1-6 SCALE



1. NO FEEDING DAMAGE

2. VISIBLE FEEDING SCARS PRESENT

3. AT LEAST ONE ROOT CHEWED TO WITHIN 1½ INCHES OF PLANT

4. ONE ENTIRE NODE OF ROOTS DESTROYED

5. TWO NODES DESTROYED

6. THREE OR MORE NODES DESTROYED

ROOT DAMAGE RATING

Applications

Assessment of root damage by larval corn rootworms; evaluation of performance of corn rootworm insecticides.

Procedure

Corn rootworm infestations can be spotty so several roots should be sampled when assessing rootworm injury. Best time to make the evaluations is after the larval feeding is over but before there has been a significant amount of root regeneration. As a rule of thumb, this is the time when adult beetles are first found on the plants, sometime in late July.

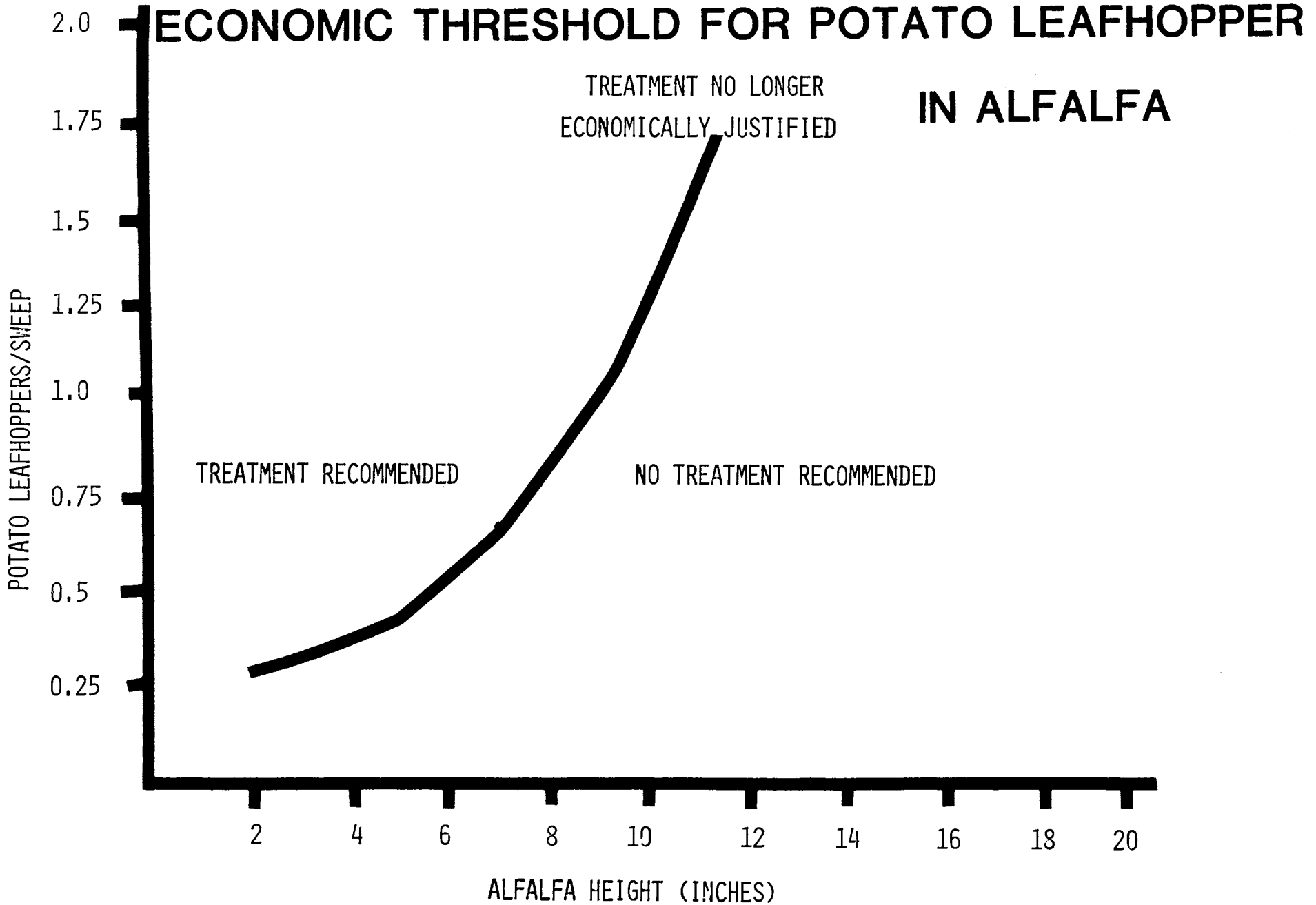
To make the root damage ratings, the roots must often be washed. However, if the soil is of the right consistency at the time of the evaluation, the soil may be sufficiently well removed by sharply striking the base of the plant.

It should be remembered that the larvae cause a chewing injury that appears as a gouging on the root surface, as root consumption, or as a tunneling of the root. Discolored or collapsed root tissue may result from pathogens, rather than root feeding by corn rootworm larvae.

The most commonly used scale for evaluating root injury is the Iowa 1-6 scale.

1	No feeding damage
2	Visible feeding scars present on some roots. No roots pruned.
3	At least one root pruned to within 1½ inches of the plant. Less than an entire node of roots pruned.
4	At least one entire node of roots pruned. Less than two root nodes destroyed.
5	At least two entire nodes of roots pruned. Less than three root nodes destroyed.
6	Three or more root nodes destroyed.

For yield reductions to occur, an average root damage rating must exceed at least 2.5. Often levels of root damage exceeding 3.5 have not resulted in yield reductions in University of Minnesota tests.


ECONOMIC THRESHOLD FOR POTATO LEAFHOPPER IN ALFALFA
TREATMENT NO LONGER ECONOMICALLY JUSTIFIED
TREATMENT RECOMMENDED
NO TREATMENT RECOMMENDED
POTATO LEAFHOPPERS/SWEEP
2.0
1.75
1.5
1.25
1.0
0.75
0.5
0.25
2
4
6
8
10
12
14
16
18
20
ALFALFA HEIGHT (INCHES)

POTATO LEAFHOPPER ECONOMIC THRESHOLD FOR ALFALFA

Recommended sampling procedure

Use a standard (15" diameter) sweep net. It should have a heavy cloth bag and be of sturdy construction.

Sample in five locations of the field, avoiding field edges where leafhopper populations tend to be highest. At each location, make 20 sweeps. Carefully open the bag and count all potato leafhoppers caught. Calculate the average number of leafhoppers per sweep.

Sampling for potato leafhopper is most important in the early regrowth stage and should begin following the first cutting. Try to avoid sampling during windy conditions or when foliage is wet.

Interpreting the economic threshold

The threshold as given shows a generalized relationship between potato leafhopper populations and economic injury. Factors which can make potato leafhopper infestations more injurious (shift the treatment guideline down and to the right) include: a high price for alfalfa hay, droughty conditions, or young fields in the first year of establishment. The main factor which reduces the economic injury by potato leafhopper (shift the treatment guideline up and to the left) is a depressed price for alfalfa hay.

CORN

Head Smut

Head smut, Sphacelotheca reiliana (Kuhn) Clint, differs from common smut, caused by Usilago maydis, in that the head smut pathogen is primarily soil-borne. The teliospores (smut spores) from the smutted tassels or ears disseminated by wind, rain and/or harvesting equipment overwinter in the soil and are the source for infection in succeeding corn crops. It is also believed that fields may be infested by planting seed contaminated with head smut spores. The head smut fungus infects the corn plant in the seedling stage. Once the plant is infected, symptoms are not exhibited until the tassel and/or ears are developed. The tassel and/or ear of infected plants are transformed into smut sori. Inside the sorus (small galls) are millions of dark brown to black teliospores. In addition to the teliospores are the remains of the vascular tissue of the tassel and ear. The vascular tissue appears as a "stringy mass". The head smut sorus, unlike the common smut sorus is not bounded by a distinct, persistent covering called a periderm. The head smut is found on ears and/or tassels and rarely on leaves, while the common smut sorus can be found on leaves, stalks, tassels, ears or on individual kernels of the ear.

This disease, discovered in Minnesota in 1980 has remained present in all locations - Wadena, Otter Tail, Stearns, and Todd counties. In 1981 the fields in Stearns county were all rotated to either soybeans or grain and no head smut was found, however, in 1982 corn on fields found with head smut in 1980 again had head smut present. The incidence of head smut has remained low and has created no serious problems in 1982. A second location in Stearns county near Clearwater was reported in 1982 which is about 30 miles east-southeast of the previously known infestation.

Since this disease was reported to usually produce a plant without a marketable ear, a direct yield loss and could be easily spread from place to place with equipment and/or seed and survive for many years in soil, projects were developed to: 1) screen for resistance (commercial lines 1981 & 1982, breeding lines 1982), 2) evaluate chemical treatments (seed and soil treatments 1981 & 1982) and to 3) define how long the fungus will survive in soil and infect susceptible corn lines.

Corn hybrids were planted in artificially infested soil on each of three planting dates, 4/28, 5/12, 5/27, 1981 and 4/26, 5/11, 5/24, 1982. These plants were examined in the fall for head smut sori on either tassel and/or ear. Data on resistant, moderately resistant, moderately susceptible, and susceptible corn hybrids was presented last year and in 1982, fewer commercial lines were tested for head smut reaction and more genetic material was evaluated. The 1982 results are not available at this time. Chemicals as seed treatments, granules over the furrow or granules in the furrow were applied in 1981 & 1982. Chemical control with registered seed treatments are of little value, however, early data from 1982 and the 1981 data indicates seed treatment or granules in the furrow with new non-registered products

can control head smut.

In Minnesota, where head smut was found, the most commonly used hybrids are thought to be some of the most susceptible. This plus continuous corn production on soil suitable for infection set up conditions favorable for the head smut fungus after it was introduced. Since the fungus is reported to survive for long periods in soil and can easily spread on equipment and seed we should continue to survey for the disease. Disease loss due to head smut has remained low and the use of resistant hybrids, and rotation offer the best means to manage this disease.

Northern Corn Leaf Blight

The long elliptical gray-green to tan colored lesions that develop first on lower leaves and progress up the plant with time can cause early death. The plants killed this way often are gray in appearance which may resemble frost or drought injury. Helminthosporium turcicum survives the winter as mycelia and conidia in infected leaves, husks and other plant parts. Disease development is favored by temperatures 18-27°C (65-80°F) and heavy dews. This disease was present on 47% of the 93 farms surveyed on 1982 with an average of 4.3% of the plants affected (Range 0.0 - 26.8%). However, as with most corn foliar diseases, severity levels were zero. Northern corn leaf blight has been managed by use of resistant lines. This resistance (Resistance gene Htl) has worked quite satisfactory until the occurrence of Race 1 of H. turcicum. This new race was present in Indiana, Illinois, New York, Ohio, Pennsylvania and in Wright county, Minnesota, 1981. At this time the status of Race 2 in Minnesota is unknown, however, Stearns county and Wright county did have the highest average incidence of Northern corn leaf blight in 1982.

Eyespot

This disease first reported in the U.S.A. in 1968 is most common in North Central and Northeastern states. The fungus, Kabatiella zeae survives the winter as resistant hyphae in infected corn residue. The following spring and throughout the growing season, fungal spores are produced and released during moist periods. Lower, older leaves are first infected and when wet weather or prolonged dew is present even the upper, younger leaves become infected. Observations in fields in late June indicate plants one foot high can have numerous lesions. The eyespot lesion is an oval-circular yellow spot which develops a brown or tan center with a ring of darker color and yellowish halo. When severe, the spots run together and the entire leaf dies.

Eyespot was found over a wide area in Minnesota. The average prevelance on 93 farms was 80.6%, however, incidence (% of plants affected) was 31.3% and severity (proportion of plant affected) was 0.6%. Fields with early severe incidence levels were generally in the central and southeast districts, however, even in this area severity was only 0.6%. This disease requires wet weather early in the season, the dry (June & July) weather and hot July and early August kept the disease from fully expressing itself. The highest severities were found in Todd and Otter Tail counties and even under these conditions yield loss should be very small.

Fields with early, severe infection levels were generally fields of continuous corn under reduced tillage. Eyespot is favored by irrigation, but not restricted to irrigated fields. Losses in inoculated plots ranged from 20-40 bushels per acre, when susceptible hybrids are grown. Losses under irrigation from natural inoculation ranged from 8-13 bushels per acre. Resistance, rotation, plow down or fungicides are promising means of disease management. (Tables 1,2, & 3).

TABLE 1.

Eyespot Disease Loss, Irrigated Corn, Staples, Minnesota

Treatment	MN 7301			W64 x W117		
	Yield Bu/A	Loss Bu/A	% Reduction	Yield Bu/A	Loss Bu/A	% Reduction
NI-S	143.3	-	-	174.7	-	-
NI-NS	132.6	10.7	7.5	161.3	13.4	7.7
I-S	123.5	19.8	13.8	153.6	21.1	12.1
I-NS	103.0	40.3	28.1	136.5	38.2	21.9

NI = Not Inoculated, NS = Not Sprayed, I = Inoculated Kabatiella zeae

S = Sprayed

TABLE 2.

Eyespot Disease Loss, Waseca and Morris, Minnesota

Treatment	MN 5201					
	Waseca			Morris		
	Yield Bu/A	Loss Bu/A	% Reduction	Yield Bu/A	Loss Bu/A	% Reduction
NI	144.1	-	-	89.6	-	-
I	103.5	40.6	28.2	69.1	20.5	22.9

NI = Not Inoculated I = Inoculated Kabatiella zeae

TABLE 3.

Eyespot Disease Loss, Irrigated Corn, Darwin, Minnesota

Hybrid	Rotation		
	Soybean-Corn No Fungicide	Corn-Corn No Fungicide	Corn-Corn Fungicide Applied
1	143.5	116.6	143.4
2	131.2	131.1	138.8
3	132.6	127.8	136.9
4	127.4	109.6	113.2
5	142.8	142.4	155.8
$\bar{X}$	135.5	125.5	137.6

Fungicide Maneb 3X.

Root Rot/Stalk Rot

Corn fields this year had less lodging than last year, but even so many concerns were expressed about corn plants that collapsed or twisted and fell down. The stress of early season dry weather and mid-season hot weather and early fall wet conditions along with wind and hail damage combined to allow Pythium to attack the plant. In September plants from several fields were found with basal stems discolored, water soaked and soft. The roots also were brown, water soaked and soft. The plant however, remains green and turgid because the vascular system is still intact and functioning. The disease is usually first recognized when the plant falls over. The stalk is often twisted and seldom broken off completely. This year in late October, many plants were observed to be green and otherwise normal in appearance yet nearly horizontal. The root system was very poor and often the brace roots had been pulled out of the soil, allowing the plant to tip. Following this primary attack by Pythium, Fusarium species colonize the decayed area and produce the typical "Pink" condition. Stalk rot then moved up the stem.

Pythium disease develops in hot 32°C (90°F) extended wet conditions. This fungus, also called a water mold does well when soil and air are wet and humid. Many roots were brown, water soaked and essentially empty tubes with no structure or strength. The rot may be prevented from further development in the stalk by node tissue at the soil line, however, as plant growth slows additional tissue is invaded by Pythium and/or Fusarium. The fungus Pythium is generally distributed wherever corn is grown and dependent upon favorable weather for expression.

ALFALFA

Verticillium Wilt

A disease of alfalfa caused by the fungus, Verticillium albo-atrum was

identified by plant pathologists at the University of Minnesota in several alfalfa fields in three counties (Carver, Sherburne, Dakota) in Minnesota in 1981. The disease known as Verticillium wilt has been a serious disease in alfalfa in northern Europe for over 30 years. In the United States it was first found in Washington State in 1976 and later in Idaho and Oregon.

Verticillium wilt was found in Wisconsin in 1980 and has now been found in 24 counties in that state. Although it is known to occur in three counties in Minnesota, it may be much more widespread. Alfalfa fields throughout the state will be examined during the next crop season to determine the distribution and severity of the disease in Minnesota. No new locations were found in Minnesota in 1982.

Symptoms of the disease are wilting leaves turning yellow while the stems remain green often even after the leaves are dead. The upper tap root and crown usually have light brown to orange streaks. After symptoms appear, the plant dies. Regrowth from infected crowns is weak and stunted.

The disease is usually not observed in an alfalfa stand until the third production year. The diseased plants are usually scattered thinly through the stand at first and, once established, depending on weather conditions and other factors, the disease may spread rapidly and deplete a stand within a year after it was observed. Generally, it is not serious in a short rotation of 2-3 production years.

The fungus can be introduced into a field in plant material with seed or within the seed itself, in manure, hay or on farm machinery or animals, including birds and humans. The most likely long distance spread is by seed that is not thoroughly cleaned. Once established in a field, the fungus spores spread during hay harvest, by wind, water or any other means from infected plants to healthy plants.

Precautions may be taken to reduce the chances of establishment or spread of the disease. Plant only well cleaned seed, Treat seed with a fungicide containing thiram to reduce the chances of introducing the fungus with the seed. The fungus can live for long periods in alfalfa stems, so hay or manure from animals fed infested hay should not be spread on producing alfalfa fields or on fields to be planted to alfalfa. Harvest the youngest fields first and the other fields or fields known to have the disease last. Before harvesting the next field, wash harvesting equipment with the garden hose after removing all plant debris.

Several varieties claimed to be resistant to Verticillium wilt have been released by seed companies and a limited amount of seed will be available for spring planting. These varieties are being tested for forage production and persistence in Minnesota as well as their resistance to other major Minnesota diseases. Resistance to other diseases and winter survival in Minnesota are still important factors when selecting a new variety.

Verticillium wilt symptoms in the field can be confused with other diseases. If the grower suspects Verticillium wilt, he should send plants and the necessary information to the Plant Disease Clinic, University of Minnesota, Room 304 Stakman Hall, 1519 Gortner Avenue, where we will test for the presence of the fungus.

Anthracnose

This disease caused by Colletotrichum trifolii infects stems and crowns and may reduce quality and stands. It is present all season but is more common after the first harvest. Scattered, straw-colored infected plants appear throughout the field. Looking in the crop canopy reveals plants that are shorter and tops which bend over forming a shepherd's crook. The best symptom is the stem lesion. A grey-brown, diamond shaped lesion with a dark border is found on the lower stem. The center of the lesion is tan or bleached and dotted with black fungal structures. The black structures contain spores and have hair-like projections which are observable with a hand lens. The lesion or several, may girdle the stem, causing wilt and death. The shape, diamond and definite border help to separate from black stem. Many samples sent last year for Verticillium wilt analysis had Anthracnose. The foliar symptom of wilt and leaf death is not a good diagnostic aid. Check for the basal diamond shaped stem lesion to help eliminate Phytophthora root rot or Verticillium wilt. Anthracnose can also invade the crown which is difficult to distinquish from other crown problems.

This fungus survives on debris and develops in warm wet weather. Spores are rain splashed and carried by the wind. Infection is more prevalent in older stands. The effects of fertility and management practices are not known. Disease reactions of alfalfa to Anthrancose as reported by Wisconsin Plant Pathologist, M. F. Heimann and C. R. Grau are presented in Table 4.

TABLE 4.

Disease Reactions of Alfalfa Varieties to Anthracnose

High Resistance	Moderate Resistance	Low Resistance	Moderately Susceptible	Susceptible
A-54	Apollo II	Blazer	A-59	Citation
DS 7801	Apollo	Classic	Agate	WL 220
Saranac AR	Cascade	Futura	Dominor	Saranac
Trumpetor	G7730	Peak	Gladiator	Anchor
Atlas	Magnum	120	Tempo	Conquest
Vangaard	Ramsey	524	WL 219	Glory
DeKalb 130	Thunder	432	WL 309	Honeyoe
Olympic	Trident	545	Primal	Marathon
WL 316	Valor		520	Nugget
	WL 311			Pacer
	Answer			Phytor
	Titan			
	Expo			

SOYBEANS

White Mold

White mold caused by Sclerotinia sclerotiorum was considered to be of minor importance however, it is a persistent fungal problem once established. Inoculum levels are increased by growing susceptible crops of sunflowers, sugar beets, dry beans or soybeans. The incidence, severity, and inoculum production is greater when fields are planted to narrow rows and/or varieties which are tall and lodge early forming a closed canopy. White mold has been observed in several soybean fields in Minnesota and can kill soybeans before maturity reducing yield.

Table 5.

DISEASED AND HEALTHY PLANT SOYBEAN YIELD, RENVILLE COUNTY, MINNESOTA

	DISEASED	HEALTHY
Pods per Plant	7	21
Seeds per Plant	14	50
Seed Wt/Plant in Grams	1.6	7.8

Since this disease was usually found in fields with sunflowers or dry edible beans in the rotation, these crops were thought to increase the field inoculum level, thereby developing a soybean disease problem. Another important hazard with this disease is the contamination of soybean seed. This fungus produces black sclerotia often the size of soybean seeds that are not separated from seeds during harvest. A small infection center in a field may now contaminate a large volume of seed. The sclerotia survives in the soil for long periods being resistant to fungicides, dry heat to 70°C (158°F) and freezing and thawing. The fungus can also survive on numerous crops and weeds. Once established in a field this disease remains a problem for a long time.

Soybeans differ in the degree of susceptibility and further observations are planned in Minnesota. Presently soybean growers should 1) avoid rotation with susceptible crops (dry beans & sunflowers), 2) plant seed free of sclerotia, 3) avoid tall, viney varieties which lodge and form a closed canopy, 4) if the field has a white mold history, plant 30" rows and 5) select varieties more tolerant of white mold.

Phytophthora Root Rot

This disease was first observed in the late forties and early fifties is becoming more important. The extent of loss depends on soil, rainfall, tillage, cultivar, being most severe in low, poorly drained, clay type soils. However, PRR may appear in lighter soils and higher ground when the soil remains wet for several days. Resistance to Race 1 and other races has been on the

standard means of disease control for several years. Reports from Ohio and other locations are now questioning the continued use of race specific resistance as more and more races are identified. The use of field tolerant soybean strains and a seed treatment to prevent seedling loss is a new alternative. The fungicides Apron or Grandstand (Ridomil Ciba-Geigy, Dowco 444 - Dow Chemical) have been used to protect the soybean seedling from early infection and appear very promising. (Tables 6 and 7).

Table 6.

PHYTOPHTHORA ROOT ROT SEED TREATMENT

WISCONSIN

Seed Steele	% Emergence	% Killed PRR	Yield Bu/A
Grandstand			
1 oz/100 lbs.	68	19	45
Untreated	62	61	27

Table 7.

PHYTOPHTHORA ROOT ROT SEED TREATMENT

WASECA

Seed Highly Susceptible	Final Stand
Apron	
2# oz/100 lbs.	25.7
Untreated	19.1

Several fields in Minnesota in 1982 were observed to have a phytophthora root rot problem even when Race 1 resistant material was used. Limited testing at this time indicates that while the most common race is still Race 1 other Phytophthora races are present. Race 4 was identified in soil from Dodge county, Minnesota.

Downy Mildew

This disease was first reported in the U.S.A. in 1923, is present most years but seldom a serious threat to soybean production. Downy mildew causes the upper surface of new leaves to develop pale green to yellow spots of indefinite size and shape. The spots turn gray brown and on the lower leaf surface in the morning, especially if moisture is present, gray mycelium and spores can be seen. The sporangiophores release gray mycelium and spores can be seen. The sporangiophores release sporangia which infect new leaves. Pod infection may not be evident externally but the interior of the pods and the seed coat are encrusted with a whitish mass of mycelia and spores. Peronospora manshurica overwinters as oospores in infected leaves and on seeds. Planting oospores encrusted seeds may produce a few systemically infected seedlings, which can further spread the disease.

This disease was observed in several fields in Minnesota in 1981 and 1982. Incidence however was judged to be very low. At harvest time 1982, several samples of soybeans were observed to have seed encrusted with a white mold-downy mildew. While there are many races of downy mildew identified in the U.S.A., resistance has performed satisfactory. Treating infested seed with a fungicide should reduce seedling infection and subsequent spread. Rotation, plowing down soybean residue or rotate soybeans with a non-susceptible crop are recommended control measures.

PREVENTING MOLD DETERIORATION OF STORED GRAIN

Space to store present grain inventories continues to be a problem. Whenever grain is stored for long periods of time, certain management practices are essential to avoid deterioration by mold or insects.

Grain deterioration begins when storage begins, with the rot of storage loss depending on storage conditions. Manipulating certain conditions such as moisture and temperature to levels where deterioration will not occur will increase to chances of marketing good quality grain.

If grains are harvested sound, subsequently kept at low moisture content and low temperature, they may retain their original processing quality and even their original germinability for a period of many years. It must be noted, however, that grains are susceptible to invasion and damage by insects, mites, and fungi; and if they are stored under conditions that promote the development and any of these organisms, extensive spoilage may occur within a few days to a few weeks.

Fungi, along with the other organisms mentioned above, play a major role in the deterioration of grain. The growth of fungi in grain can cause loss in weight, grade, and seed germination. They are the cause of heating (bin burning) mustiness and mycotoxin production. Preventing the growth of these fungi will in turn prevent these losses from occurring.

The most generally used successful storing system is to keep the grain at moisture contents lower than fungi can grow, then maintain these moisture contents throughout the bin. Table 1 indicates some of the safe moisture contents recommended for starchy seeds and some oil seeds. A combination of low moisture and low temperature is another method common to use. Cooling grain to 35^{o}F is effective in slowing the growth rate of the storage fungi.

Temperature, moisture, amount of foreign matter, insect invasion and previous invasion by fungi are all factors that determine the storability and quality of grain. When the moisture content of a lot of grain increases, it's storability will decrease as the temperature increases. Table 2 shows the approximate storage life of lots of grain that exist in normal market channels, at various temperatures and moisture contents.

When handling freshly harvested corn of high moisture, the temperature or the moisture content must be lowered to assure safe continued storage. The allowable storage time for this shelled corn at various temperatures and moisture contents is shown in Figure 1. The obvious difference between the allowable storage time and Figure 1 as compared to Table 2, are due to differences in the condition of the grain at time of acquisition. In normal market channels the grain received is a mixture of various lots that were stored for different times under various storage conditions. This mixing enhances the possibility of increasing foreign matter, insect invasion, and previous invasion by fungi. An increase in any of these factors decreases storability of the grain.

When storing grain it is important to remember that spoiling grain emits heat. Temperature detecting equipment in bins will detect this heat, indicating deterioration in the area where temperatures are rising. Records should

be kept on the temperature in the bin, and any increases in temperature should be noted. A steady rise in temperature means trouble and should be dealt with immediately.

The moisture content of grain should be checked as it goes into the bin and should be monitored during storage with any increase noted and corrected. One should know the range of moisture content in the bin as the average moisture content does not always give a true picture of storability. Uniform sampling of grain in a particular storage structure will help determine the range of moisture content in a bin. Figure 2 gives one example of a procedure to accomplish this.

Moisture content determination is only as accurate as the moisture meter used. Many bins of grain have spoiled because of inaccurate moisture meters. Each moisture meter should be checked with other moisture meters in nearby State or Federal or local elevators to check variations. Variations from 2 or more different moisture meters definitely indicates a problem. Moisture meters can also calibrate against the dry procedure of moisture content determination. The oven dry method is to determine amount of weight loss in a sample of grain after heating at $103^{o}C$ for 72 hours (for starchy seeds).

Aeration greatly improves the storability of grain by maintaining a cool, uniform temperature throughout the storage to reduce mold development and insect activity and to prevent moisture migration. Moisture migrating from a warm area of the bin to a cooler area may result in spoilage and severe deterioration of grain quality. Aeration should provide for a cool down period for winter storage and a spring warm up period for summer storage. For more information on management of stored grain with aeration consult Agricultural Extension Service Folder M-165 obtainable from the Bulletin Room at the University of Minnesota, St. Paul Campus.

Eliminating insect and mite problems are also very important in mold control. Any insect infesting the grain will give off moisture which will collect on the surface of the grain. This can bring the moisture limits up to levels which will prevent mold growth.

Following procedures are recommended to monitor grain in storage in Minnesota:

1) Make sure the grain at the top of the bin (in round bin storage) is level. This makes aeration much less difficult.

2) Good aeration management must be followed according to the direction given in "Management of Stored Grain With Aeration", Agricultural Extension Service, M-165.

3) The spot line containing fines should be drained off the bottom of the bin. This will decrease the chances of spoilage in the center of the bin.

4) Check each structure at least once a month for a) moisture content changes on the top of the bin or in the case of bulk storage in the peak of the pile, b) monitor for temperature changes in the top of the bin

or on the peak of the pile and bulk storage, c) check for any tell-tale musty odor in any part of the bin or the air exhausting from the aeration fan, d) check for leaks or any unusual situation that would cause unusual moisture content accumulation or temperature differences within the bin structure.

5) Make sure that the aeration fan opening is covered with a board during times when the fan is not in operation. This will eliminate extreme hot and cold temperature changes in the aeration ducts and prevent mold from growing in the area.

6) Moisture content determinations as recommended in Figure 2 should be done initially and at least every six months in long term storage.

When obvious spoilage is detected, regardless of the storage methods used, the grain should be cooled by aeration to a level stopping the fungus growth ($35^{o}F$). If aeration is not possible, the grain should be emptied from the bin and dried before continued storage.

If further management information is needed, order Bulletins M-161, M-162, M-163, M-164, M-165, and M-166 from the Agricultural Extension Service, Bulletin Room, 3 Coffey Hall, University of Minnesota, St. Paul, Minnesota 55108.

Table 1.

MOISTURE CONTENTS FOR SAFE STORAGE MAINTAINED IN ANY CLIMATE

	M.C.%
Starchy seed (wheat, barley, corn, sorghum)	13.0
Soybeans	12.0
Flaxseeds	10.0
Sunflower Seeds	8.5
Meats	5.0

Table 2.

APPROXIMATE PREDICTIONS ON SAFE STORAGE LIFE

Grain Temperature of	Moisture Content % 14	15.5	17	18.5	20
50	256	128	64	32	16
60	128	64	32	16	8
70	64	32	16	8	4
80	32	16	8	4	2
90	16	8	4	2	1
100	8	4	2	1	0

1) Bailey, J. E. 1974. Whole Grain Storage, In. Storage of Cereal Grains and Their Products, C. M. Christensen ed., 549 P.

Allowable storage time for shelled corn at various temperatures and moisture contents. During these times the grain will lose 1/2 percent in dry matter, but will still be acceptable. (Corn lots were aerated to maintain given temperature and moisture condition for days specified).

FIGURE 1.

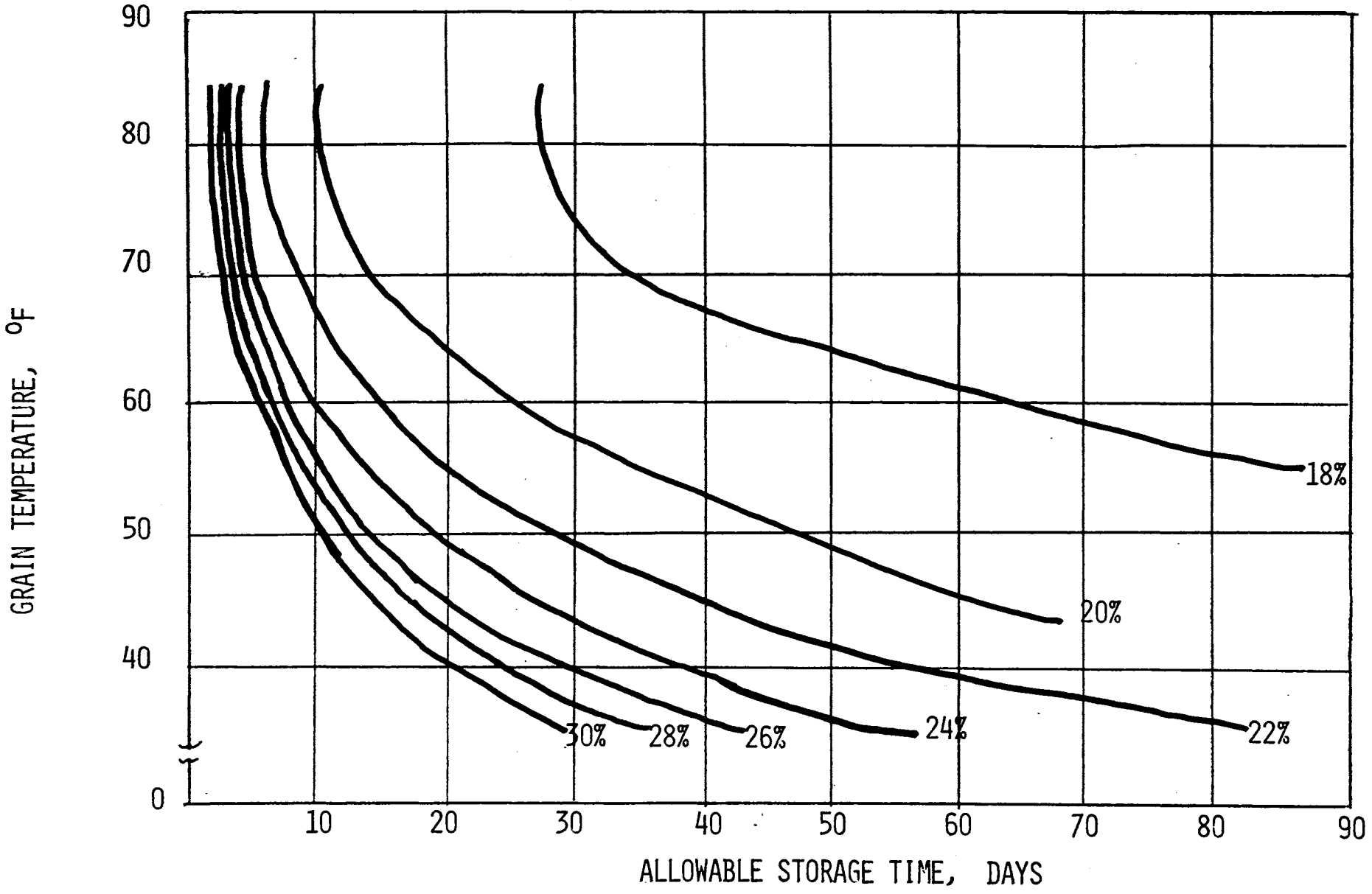


Figure 2.

GRAIN SAMPLING PROCEDURE FOR A MORE ACCURATE DETERMINATION OF GRAIN CONDITIONS THROUGHOUT THE BIN.

I. Sampling procedures.

a) Each sample should consist of enough corn, representative of the collection area, to fill a pint jar (this will be enough for a moisture test).

II. Round Bin

1) Top of peak if peaked, otherwise center surface.
*2) Center probe.
*3) Probe sample on south side of bin collected 1-2 feet from bin wall.
*4) Probe sample on north side of bin collected 1-2 feet from bin wall.
5) Sample any obviously moldy area.

*Using a probe, collect grain at 1 feet intervals down to 6 feet. Mix sample and take out 1 pint for testing moisture.

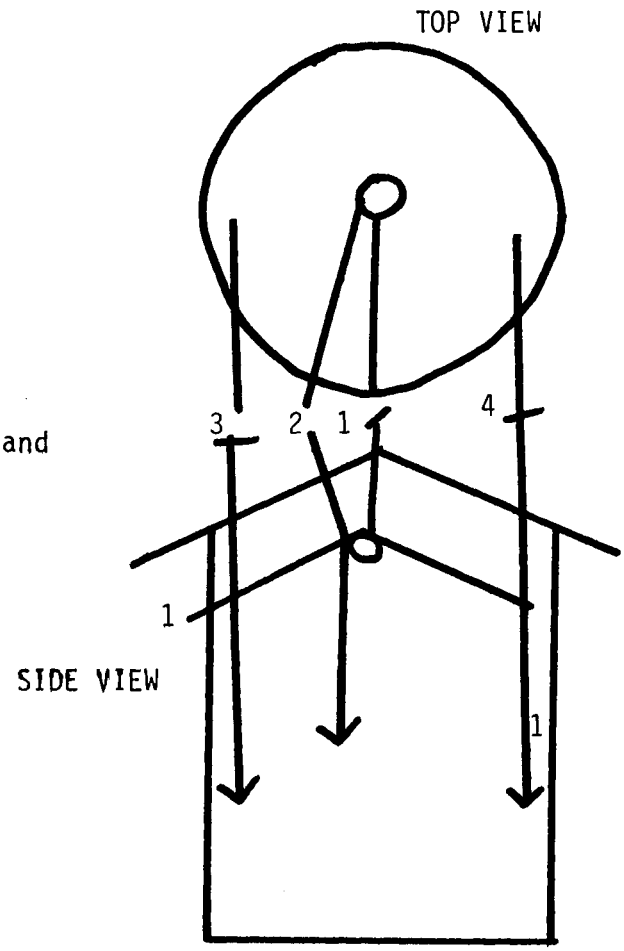
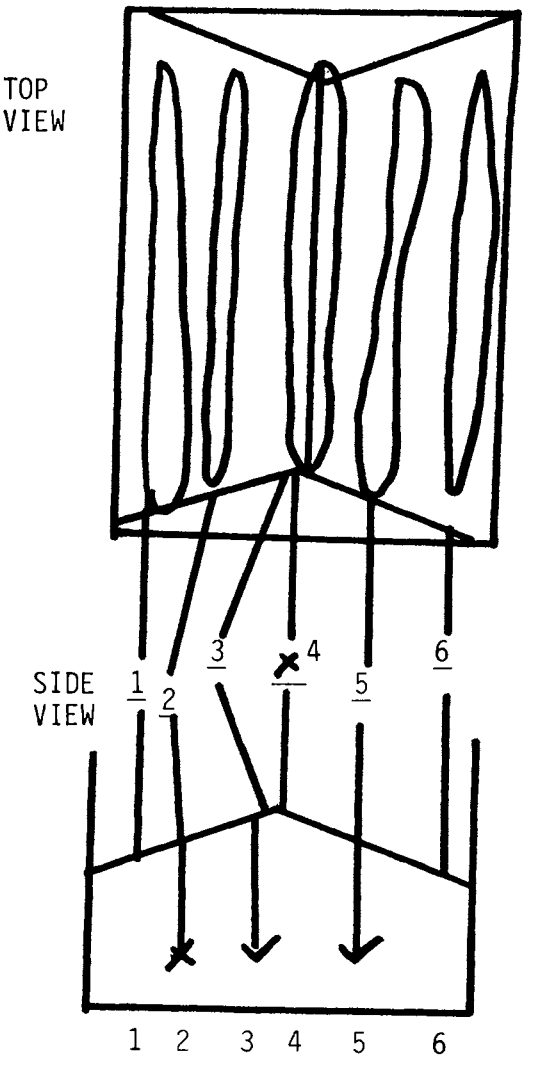


Figure 2.
cont'd.

III. Flat Storage with Peak.

*1) Surface to 1 foot, sample from edge of pile 1-5 feet from edge of bin.
**2) Probe sample midway between peak and sidewall.
**3) Center probe.
*4) Surface peak to 1 foot down.
**5) Same as 2, opposite side.
*6) Same as 1, opposite side.
7) Sample any obviously moldy area.



* Grain should be collected every 15 feet (or fraction thereof) along the designated areas, mix sample and take out 1 pint for moisture testing.

** Probe every 15 feet (or fraction thereof) along the designated areas. At each probe site collect grain at 1 ft. intervals down to 6 feet. Mix sample and take out 1 pint for moisture testing.

IV. Draw a sketch of your structure noting areas where samples were taken. Make sure the numbers on the sample packages correspond with the numbers designating the site where the sample was taken.

TABLE I. CHEMICALS FOR DISEASE CONTROL IN DRY BEANS

CHEMICAL	LABELED USE*	RATE	COMPANY
Foliar Sprays			
Fungus Diseases			
Bravo 500	rust , Anthracnose, downy mildew	2-3 pts/acre	Diamond Shamrock
Dithane M-22	rust, downy mildew	1-3 lbs/acre	Rohm & Haas
Dithane M-22 Special	rust, downy mildew	1-3 lbs/acre	Rohm & Haas
Dithane Z-78	rust, Anthracnose , downy mildew	3-4 lbs/acre	Rohm & Haas
Kocide 404S	bacterial blight, halo & common rust	1-3 qts/acre	Kocide Chemical Corp.
Benlate	white mold grey mold	1½-2 lbs/acre 1-2 applications	Dupont
Maneb 80	Anthracnose & downy mildew	1.9 lbs/acre	Pennwalt
Topsin-M	white mold grey mold	1.5-2 lbs/acre once or twice	Pennwalt
Dichlone 50WP	Anthracnose	1-½ lbs/acre	FMC
Kalospray	powdery mildew, leaf spot rust	4-7 lbs	FMC
Zineb 75 wettable power	rust, Anthracnose	1½-2 lbs	FMC
Manex	Anthracnose, downy mildew, rust	1.2-1.6 qts/acre	Griffin Corp.
Citco Tri-Basic Copper Sulfate	angular leaf spot Anthracnose bacterial blight downy mildew	2-4 lbs/acre	City Service Co.

*Check label for special restrictions as to use and time before harvest.

Table 1. Cont.

CHEMICALS FOR DISEASE CONTROL IN DRY BEANS

CHEMICAL	LABELED USE*	RATE	COMPANY
Seed Treatment			
Lesan	seed rot, damping off	1 gal/100 lbs. seed	Mobay
Captan	seed treatment, damping off, soil treatment	see Label	Chevron Stauffer; Hopkins Guftufson Inc.
Hopkins bean seed protectant	seed treatment - labeled in Michigan, Nebraska, New York, North Dakota, & Wisconsin only.	3 oz/bu	Hopkins Chemical Co.
Diazinon - Captan seed protectant	seed treatment, damping off and seedling blight	3 oz/bu	Hopkins Chemical Co.
Agrox - 3-way	damping off, seed decay, seed corn maggot and wireworm	3 oz/bu planter box	ICI, U.S. Inc.
Arasan 50-Red	seed treatment, seed decay, damping off, seedling blights	1/3 tsp/lb seed	Dupont
Arasan 50-Red ND	seed treatment, seed decay, damping off, seedling blights	1/3 tsp/lb seed	Dupont
Arasan 70-S	seed treatment, seed decay, damping off, seedling blights	230 cc/cwt seed	Dupont
Demasan 65W	seed treatment, seed decay, damping off, seedling blights	6 oz/100 lbs seed	Dupont
Agrox 2-way	damping off, seed decay	3-1/3 oz/cwt	ICI, Chipman Chemical
Agri-Strep 500 62.6%	seed rot, halo blight	8 oz/100 lb seed	Merck & Co.

* Check label for special restrictions as to use and time before harvest

DRY BEAN DISEASES

Diseases were a factor in dry bean losses again this year. The most serious ones were White Mold, Rust and Alternaria leaf spot. Anthracnose was also confirmed as present this year.

White Mold

White mold, (caused by Sclerotinia sclerotiorum) is a persistent problem in dry bean production, especially with the increased number of dry bean acreages and the tendency to shorten rotation periods. The last three years white mold has caused substantial losses within the dry bean area.

White mold is a fungus disease which is most serious during wet weather. The wind blown fungus spores colonize dead bean tissue (dried blossoms, leaves), then proceed into living tissue causing a watery soft rot. The characteristic symptoms of white mold are a white cottony growth on the surface of decaying tissue. Some of the fungus growth will develop into dark hard bodies called sclerotia. Sclerotia survived adverse (winter) conditions in the field. The disease probably will be noticed when the plant growth covers the space between the rows and when the soil surface is cool and moist enough for sclerotia to germinate. Infected plants will often wilt rapidly and appear bleached. Infected seed is discolored (often orange and chalky) and is light-weight.

Crop rotation helps prevent the build-up of enough inoculum to cause white mold in edible beans. A rotation of 3-4 years between beans and other susceptible crops is recommended. Sunflowers, potatoes, sugarbeets, and soybeans should not be grown in close rotation with edible beans since they are susceptible to white mold. Small grains, corn, or forages are recommended in a rotation with edible beans to prevent increase of white mold inoculum.

One or two applications of the fungicides Benlate or Topsin - M have provided good control of white mold. When applying this fungicide, it is important that the first application be made when the field is in 10-25 percent bloom, and the second application should be made after the full bloom stage or during late bloom. Fungicide applications should be considered if white mold has been a problem on or near the farm in previous years, or when cool conditions are forecast for the last month of the growing season.

For effective results, fungicide applications for control of this disease MUST be made before the disease is obvious. Management decisions concerning applications at this early stage of growth are sometimes difficult to make, therefore, it is important to use the guidelines previously mentioned. These fungicides are systemic, are absorbed in the plant, and migrate from the bottom of the plant to the top. Complete coverage of plants with these fungicides is necessary for best effect.

Rust

Rust on pinto beans was again prevalent during the last growing season. Specific fields which were not sprayed, or sprayed too late did not yield near their potential. Losses due to this disease can be devastating.

Rust first appears as small chlorotic pale spots, (lesions), usually slightly yellow with a small dark center. As the disease progresses, the spots enlarge and are covered with a brick red rust (summer) spores, which spread the disease. With cooler weather, these lesions will develop black, (overwintering) spores.

Bean rust is caused by the fungus (Uromyces phaseoli var. typica) and symptoms appear 10-15 days after infection. The earlier these symptoms appear, the greater the potential for crop yield reproduction.

Cultural practices are important in slowing initial infection by this fungus. Three to four years rotations are recommended to help control this disease. Following bean harvest, all refuse should be plowed under as completely as possible as soon as convenient, because refuse is a primary source of inoculum for the next year's growing season. Chemical control of early rust infection can be accomplished when the disease is identified in the early stages. Fungicides, such as Coppers, Manebs, Zineb and Bravo will control the disease. The chemicals used to prevent rust infection on pinto beans are protectants. They will not cure the disease already present, but will help prevent spread and subsequent infection.

Rust has been discovered on Fleetwood navy beans and Olathe pinto beans this year. In the past, they have shown a great deal of resistance to the races present in this area, however, new races may have developed. Dr. Jim Groth, Department of Plant Pathology is now examining these collections to determine if indeed these are new races. This discovery suggests that we should start monitoring the Olathe and Fleetwood fields for rust and initiate spray programs when the disease is found.

Anthracnose

Anthracnose has been found in some research plots of pintos and one commercial field of Fleetwood navy beans this past year.

The symptoms found were primarily on the pods. These lesions first appear as flesh to rust, colored lesions which develop into sunken cankers (1-10 mm dia) delimited by a slightly raised black ring surrounded by a reddish brown border. The lesion center is light colored which may contain a gelatinous mass of flesh - colored conidia. The center of the lesion upon aging may die down to a gray-brown to black color. Lesions are also found on leaves and may develop initially on leaf petioles and the lower surface of the leaves and leaf veins. They appear as small, angular, brick-red to purple spots which become dark brown to black.

This can be a serious disease greatly affecting yield. The fungus is seedborne therefore, any seed form infected fields should not be used as seed again the following year. The fungus also survives in crop refuse so it is important to bury infected crop residue and follow a 3 year rotation to minimize problems from inoculum from residue. Fungicides can help prevent spread in infected fields.

Alternaria Leaf Spot

Alternaria leaf spot was found in many commercial fields of dry beans this past year. Leaf symptoms of this disease appear as small reddish brown, irregular shaped spots or flecks which are surrounded by a thin dark brown border. The lesions enlarge and may develop as concentric rings, which may become brittle and fall out, leaving a shot hole appearance. Lesions may coalesce and cover large areas of the leaf resulting in partial or premature defoliation. The fungus also can blemish leaves and pods by producing a brown discoloration on the surface and damage developing seeds. Alternaria spores are produced abundantly in the lesion. A hand lens or microscope are needed to detect these spores but when found can be used for diagnosis. The spores are club shaped with many transverse and longitudinal septations. These club shaped spores are borne singly or in chains of 2-3 spores.

Diseases are often a limiting factor in dry edible bean production, therefore, everything possible must be done to control them. Cultural practices, such as burying the bean refuse and rotation with acceptable crops are a must if dry beans are to be one of the crops grown.

Chemical control is also an important tool in disease control (Table I) and there are some varieties of the common bean types that show some disease resistance (Table II). An integrated use of all control methods available is best as in the long run it will bring the greatest return.

Table 2. Edible bean varietal characteristics and disease response[1/]

Class Variety	Origin[2/]	Plant characteristics: Maturity[3/]	Growth habit[4/]	Lodging response[5/]	Flower color[6/]	Disease response[7/]: Blight: Common & fuscous	Halo	Rust	Air pollution	Root rot	White mold	Curly top	Mosaic: $CBMV_1$	$CBMV_{15}$	Anthracnose: Alpha	Beta	Gamma	Delta
Adzuki																		
Dainagon	J	F	UB	G	Y	R	R*	R	T	S	S							
Hayate	J	M	UB	G	Y	R	R*	R	T	S	S							
Hokaido	J	F	UB	G	Y	R	R*	R	T	S	S							
Kasho	J	F	UB	G	Y	R	R*	R	T	S	S							
Minoka	UM	F	UB	G	Y	R	R*	R	T	S	S							
Sakae	J	F	UB	G	Y	R	R*	R	T	S	S							
Takara	J	F	UB	G	Y	R	R*	R	T	S	S							
Black turtle																		
Black Beauty	SVC-RB	F	SV	F	P	S	T	R	T	T	S	-	R	R	S	S	R	S
Black Magic	MSU	F	USV	E	P	S	T	R	T	T	T	-	R	R	S	S	R	S
Black Turtle Soup	CU	F	SV	F	P	S	T	R	T	T	S	-	S	S	S	S	R	S
Carbon	PR	F	SV	G	P	S	R	-	-	T	-	-	R	R	-	-	-	-
Domino	MSU	F	USV	E	P	S	T	R	T	T	T	-	R	R	S	R	R	R
Ebony	WE	F	SV	F	P	S	T	R	T	T	S	R	R	R	-	-	-	-
Midnight	CU	F	USV	E	P	S	T	R	T	T	T	-	R	R	S	R	R	R
T-39	UCD	F	SV	G	P	S	T	R	T	T	S	-	R	R	S	S	R	S
Cranberry																		
Michigan Improved Cranberry	MSU	M	V	-	-	S	S	T	T	S	S	-	S	S	-	S	S	-
Taylor Hort	W	M	B	-	-	S	S	T	T	S	S	-	S	S	-	S	S	-
Dark red kidney																		
California DRK	UCD	F+	B	E	P	S	S	T	T	S	S	-	S	S	R	S	S	S
Charlevoix	MSU	M	B	E	P	S	S	T	T	S	S	-	S	S	R	R	S	S
Montcalm	MSU	M	B	E	W	S	R	T	T	S	S	-	R	R	-	S	-	-
Royal Red	USDA-P	F	B	G	P	S	S	T	T	S	S	-	R	R	-	R	R	-

* All varieties of adzuki are susceptible to an additional bacterial blight caused by Pseudomonas syringae.
* All varieties of adzuki are susceptible to Fusarium oxysporum.

Table 2. cont'd.

Class Variety	Origin[2]	Plant characteristics				Disease response[7]												
						Blight							Mosaic		Anthracnose			
		Maturity[3]	Growth habit[4]	Lodging response[5]	Flower color[6]	Common & fuscous	Halo	Rust	Air pollution	Root rot	White mold	Curly top	$CBMV_1$	$CBMV_{15}$	Alpha	Beta	Gamma	Delta
Light red kidney																		
California LRK	UCD	F+	B	G	P	S	S	T	T	S	S	-	S	S	-	S	S	S
LKR 0688	MSU	E	B	G	W	S	R	T	T	S	S	-	R	R	S	S	-	S
Manitou	MSU	F+	B	G	P	S	S	T	T	S	S	-	S	S	-	R	S	S
Mecosta	MSU	F+	B	G	W	S	R	T	T	S	S	-	R	R	R	-	-	S
Redkloud	CU	E	B	E	W	S	R	T	T	S	S	-	R	R	S	S	R	S
Redkote	CU	M	B	G	W	S	R	T	T	S	S	-	R	R	S	S	-	S
Sacramento	UCD	E	B	E	P	S	S	T	T	S	S	-	S	S	-	S	S	-
Navy																		
Admiral	ISB	M	UB	G	W	S	R	R	S	S	S	-	R	R	-	-	-	-
Arctic	CM	VE	B	G	W	S	R	S	S	S	S	-	R	S	-	S	R	S
Bos'n	ISB	E	B	G	W	S	R	R	S	S	S	R	R	R	-	-	-	-
Bunsi	C	M	SV	F	W	S	S	T	T	S	S	-	R	R	S	S	S	S
Captain	ISB	M	B	G	W	S	R	R	S	S	S	R	R	R	-	-	-	-
Charity	CM	M	B	G	W	S	R	S	S	S	S	-	R	S	R	R	S	S
Fleetwood	A-C	F	B	F	W	S	R	S	T	S	S	-	R	R	R	R	R	S
Fleetwood 80	A-C	F	B	F	W	S	R	S	T	S	S	-	R	R	R	R	R	R
Gratiot	MSU	M	B	G	W	S	R	S	S	S	S	-	R	R	R	R	R	S
Kentwood	A-C	M	B	G	W	S	R	S	S	S	S	-	R	S	R	R	R	S
Kentwood 80	A-C	M	B	G	W	S	R	S	S	S	S	-	R	R	R	R	R	R
MSU C-15	MSU	F	UB	VG	W	S	R	S	T	S	S	-	R	R	R	S	R	S
MSU C-20	MSU	F	USV	VG	W	S	R	R	T	S	S	-	R	R	S	S	R	R
Neptune	MSU	M	USV	VG	W	S	R	R	T	T	T	-	R	R	S	S	S	S
Sanilac	MSU	M	B	G	W	S	R	S	S	S	S	-	R	S	R	R	R	S
Seafarer	MSU	E	B	G	W	S	R	S	S	S	S	-	R	R	R	R	R	S
Seafarer 80	A-C	E	B	G	W	S	R	S	S	S	S	-	R	R	R	R	R	R
Seaway	MSU	E	B	G	W	S	R	S	S	S	S	-	R	R	S	R	R	S
Snow Bunting	CM	M	B	G	W	S	R	S	S	S	S	-	R	S	R	R	S	S
Snowflake	CM	VE	B	G	W	S	R	S	S	S	S	-	S	S	R	S	S	S
Swan Valley	MSU	F	USV	G	W	S	R	R	T	T	T	-	R	R	S	R	R	R

Table 2. Cont.

Class Variety	Origin[2]	Plant characteristics				Disease response[7]												
						Blight							Mosaic		Anthracnose			
		Maturity[3]	Growth habit[4]	Lodging response[5]	Flower color[6]	Common & fuscous	Halo	Rust	Air pollution	Root rot	White mold	Curly top	$CBMV_1$	$CBMV_{15}$	Alpha	Beta	Gamma	Delta
Navy (continued)																		
Tuscola	MSU	F	B	G	W	S	R	S	S	S	S	-	R	R	R	R	R	S
Upland	CM	M	B	G	W	S	R	S	S	S	S	-	R	S	R	S	S	S
Pink																		
Gloria	USDA-P	M	V	P	W	S	S	S	S	T	S	-	R	R	-	-	-	-
Rosa	USDA-P	M	V	P	W	S	S	S	S	T	S	-	R	R	S	S	S	S
Sutter	UCD	M	V	P	W	S	S	S	S	T	S	-	S	S	-	-	-	-
Viva	USDA-P	M	V	P	W	S	S	S	S	T	S	-	R	R	-	-	-	-
Pinto																		
Columbia	UDSA-P	M	V	P	W	S	R	S	S	S	S	-	R	R	S	S	S	S
D-77213	RB	M	B	G	W	S	R	S	S	T	S	-	R	R	-	S	S	-
Fiesta	ISB	M	V	P	W	S	-	S	-	S	S	R	R	R	-	-	-	-
Gala	ISB	E	V	-	W	S	R	S	S	S	S	R	S	S	-	R	S	-
Olathe	CSU	M	V	P	W	S	R	MR	S	S	S	-	R	R	S	S	S	S
Ouray	CSU	M	B	F	W	S	R	S	S	S	S	-	R	R	S	R	R	S
Pindak	NDSU-USDA	M	C	P	W	S	R	T	S	T	S	R	R	R	-	-	-	-
San Juan	CSU	F	V	P	W	S	R	S	-	T	S	-	R	R	S	S	S	S
UI-111	UI	E	V	P	W	S	R	S	S	S	S	R	R	S	S	S	S	S
UI-114	UI	M	V	P	W	S	R	S	S	T	S	R	R	R	S	S	S	S
Wyoming 166	UW	M	V	P	W	S	R	S	S	S	S	-	-	-	-	-	-	-
410	USDA-P	F	V	P	W	S	R	S	-	R	S	-	R	R	S	S	S	S
590	USDA-P	F	V	P	W	S	R	S	S	T	S	-	R	R	-	-	-	-
Small red																		
Big Bend	USDA-P	F	V	P	W	S	R	S	S	T	S	-	R	R	S	S	S	S
NW 59	USDA-P	F	V	P	W	S	R	S	S	T	S	R	R	R	-	-	-	-
NW 63	USDA-P	F	V	P	W	S	R	S	S	T	S	-	R	R	S	S	S	S
Rufus	USDA-P	F	V	P	W	S	R	S	S	T	S	-	R	R	S	S	S	S

Table 2. Cont.

Class Variety	Origin[2]	Plant characteristics				Disease response[7]												
						Blight							Mosaic		Anthracnose			
		Maturity[3]	Growth habit[4]	Lodging response[5]	Flower color[6]	Common & fuscous	Halo	Rust	Air pollution	Root rot	White mold	Curly top	$CBMV_1$	$CBMV_{15}$	Alpha	Beta	Gamma	Delta
Small red (continued)																		
UI 34	UI	F	V	P	W	S	S	S	S	S	S	R	R	R	-	-	-	-
UI 36	UI	M	V	P	W	S	S	S	S	S	S	R	R	R	-	-	-	-
UI 37	UI	E	V	P	W	S	S	S	S	S	S	R	R	R	-	-	-	-
Small white																		
Atlas	SV	F+	V	P	W	S	R	T	T	T	S	R	R	S	-	-	-	-
Aurora	CU	M	SV	F	W	S	R	T	T	T	R	-	R	R	-	R	E	-
Bonus	SV	F+	V	P	W	S	R	T	T	T	T	R	R	S	-	-	-	-
Chief	SV	F+	V	P	W	S	R	T	T	T	S	R	R	R	-	-	-	-

[1]Adapted from "Seed Notes — Dry Edible Bean Varieties Compared," *Michigan Bean Commission Journal,* November 1981.

[2]**Origin:** A-C = Agriculture Canada
C = Colombia, South America
CM = Clarence Muehlfield, Michigan
CSU = Colorado State University
CU = Cornell University, Ithaca, New York
CU-V = Cornell University, Venezuela
ISB = Idaho Seed Bean Co., Twin Falls, Idaho
J = Japan
MSU = Michigan State University
NDSU = North Dakota State University/U.S. Department of Agriculture
PR = Puerto Rico
RB = Rogers Bros. Seed Co., Twin Falls, Idaho
SVC = Stokely Van Camp
SVC-RB = Stokely Van Camp and Rogers Bros., Twin Falls, Idaho
UCD = University of California, Davis
UI = University of Idaho
UM = Agricultural Experiment Station, University of Minnesota
USDA-P = U.S. Department of Agriculture, Prosser, Washington
UW = University of Wyoming
W = Wickes Agriculture, Saginaw, Michigan
WE = Wilbur-Ellis

[3]**Maturity:** VE, very early; E, early; M, medium; F, late; F+, very late.

[4]**Growth habit:** B, bush; UB, upright bush; USC, upright short vine; SV, short vine; V, vine.

[5]**Lodging resistance:** F, fair; G, good; VG, very good.

[6]**Flower color:** W, white; P, purple; PK, pink; Y, yellow.

[7]**Disease response:** S, susceptible; T, tolerant; R, resistant.

CEREAL CROPS

Scab did occur on the cereal crops this year, however, the disease was of little importance. You will read or hear about the serious scab problem on wheat in 1982, but this problem is in reference to winter wheat in Nebraska and Kansas.

The leaf spot diseases, Tanspot and Septoria leaf blotch were as common as usual this past season. In addition, we also found leaf rust in June on many of the early planted wheat fields. With the wet conditions it was expected that the rust might develop into a problem. Most of our Spring wheat varieties have adult plant resistance, so finding rust on the young plants was not exceptional. The amount of rust that was found so early in the growing season caused concern. As July dried-off and the adult plant resistance "took hold", the disease was stopped. However, there were some exceptions with the very late planted wheat, which did rust on it at harvest.

In general the barley crop showed the value of leaf spot resistance among the different varieties. Larker, was heavily infected with the various leaf spotting fungi while the new varieties were only slightly affected.

During this winter, you may hear or read about a cereal leaf disease called Cephalosporium stripe. This disease is primarily found on Winter wheat, especially when the crop is growing in a wet condition. The environmental requirements necessary for this disease to develop are such that our winter weather will probably prevent the disease getting started here.

Disease control practices to reduce or avoid crop loss start with using good seed, as disease-free as possible. Treating the seed with a seed treatment fungicide to protect it while in the soil before growth begins. As many of the leaf spotting diseases are carried over from season to season on infected plant debris, the new crop should be planted on clean ground, preferably in a rotation system not following wheat or corn. If wheat must be planted on old wheat land, the plant debris should be buried.

During the early part of the growing season, the crop should be examined for stand and evaluated for potential yield. If sufficient fertility is available, the stand is good, and the growing conditions are favorable or expected to be favorable for producing a good crop than a grower should make a decision on whether or not to utilize the fungicide leaf spot control program. This practice will only reduce or prevent the crop loss that can occur from leaf spotting diseases. Unfortunately, we do not have a system to evaluate the potential disease loss that may result from plant diseases that could be used before it is too late to apply a chemical control measure. Therefore, the use of this disease control practice will be based on potential yield, favorable growing conditions, past cropping experience with leaf disease and cultural practices.

In applying the fungicide to the crop it is most important that the applicator in the case of aerial application, does not use less than 5 gallons of water per acre. The applications must start before heading, usually when the leaf spots do not appear to be of any consequence.

In some 1982 field trials, fungicide treatment resulted in 15% more yield than the untreated parts of the field. A grower - county agent demonstration, using a modified ground sprayer, resulted in almost 30% yield response.

Every year, observations of root rot, are reported. These below ground diseases are very difficult to evaluate because usually a complex of pathogens are involved. It has been reported that the Pythium fungus alone can account for a 15% crop loss. Knowing that there are several other fungi, which may affect the wheat plant root system we might summarize that a 20% reduction in yield annually is not uncommon. The use of systemic fungicides in experiments for the control of leaf spot diseases suggests that other fungi in the plant may also be affected. These other fungi might well be these root rot pathogens to which we are referring.

SUGARBEETS

Cercospora leaf spot was again the disease of primary concern for the beet grower this year. The disease occurred from the Iowa border to Drayton, North Dakota. The severity of the disease lessened as the crop is traced to the northern areas. Within the beet growing area there were small local areas where the disease was present but did not develop into a major problem. In one such area, around Hendrum, Minnesota, a large 80 acre cooperative experiment was abandon because of lack of disease.

In general, most fungicide treatments were economically beneficial to growers. Some growers expressed concern that the disease was not as severe as it was expected to be this year. However, one must remember that every grower, scout and fieldman and neighbor was out in the field looking for the first symptoms, and more important - fungicide treatments were made on time, early, rather than late this year. There should have been less disease.

Disease control practices can and do work if no short-cuts are taken. Early detection is important, proper application is essential for chemical treatments to be beneficial. We have been extremely concerned about variety selection, fungicide selection and rightly so - however, the application technique is just as important. Some aerial application of less than 5 gallons per acre were observed, giving less than adequate disease control. The general aerial and ground applications were successful in keeping the Cercospora leaf spot disease in check this year.

In research tests, under extremely severe disease conditions, four applications reduced losses by 4 to 5 tons per acre with 2% better sugars.

POTATOES

The past season's potato disease picture was certainly a mixed bag. In a few words, yields were not too good - diseases were good and the weather was all screwed up!

Several growers got involved with ring rot. The crop experienced some ring rot in 1981 and more in 1982. This is a seedborne disease, readily spread by various types of contact contamination, which is usually the result of

taking short-cuts, and the type of equipment that is used in the production of the potato crop.

Early blight was it's old self again. By the second week in July, early blight had been found in the 3 major potato growing areas. In the Hollendale area the disease developed rather slowly and did not get to 70% incidence until late August. On the Sand Plains, the disease got started the second and third week of July and increased to 10% incidence in about one week. In the Valley the disease was a few weeks behind the Sand Plains. The south end of the Valley first saw early blight about the middle of July, however, 100% incidence did not occur until the middle of August. While in the north end of the Valley, early blight started about a week later, and didn't reach 100% incidence until September (See Figure 1). At this time we do not have the effects of this disease crop yield.

Late blight was found in the northern areas of the Valley. Very good to excellent eradication and control was obtained with Ridomil fungicide application. This fungicide, a systemic, is an excellent chemical for use to eradicate or stop late blight. However, this fungicide does not control early blight. To protect the life of this systemic fungicide it might be best advised not to use it as a regular fungicide, use with a mixture such as the maneb-type fungicides might be the best way to use it.

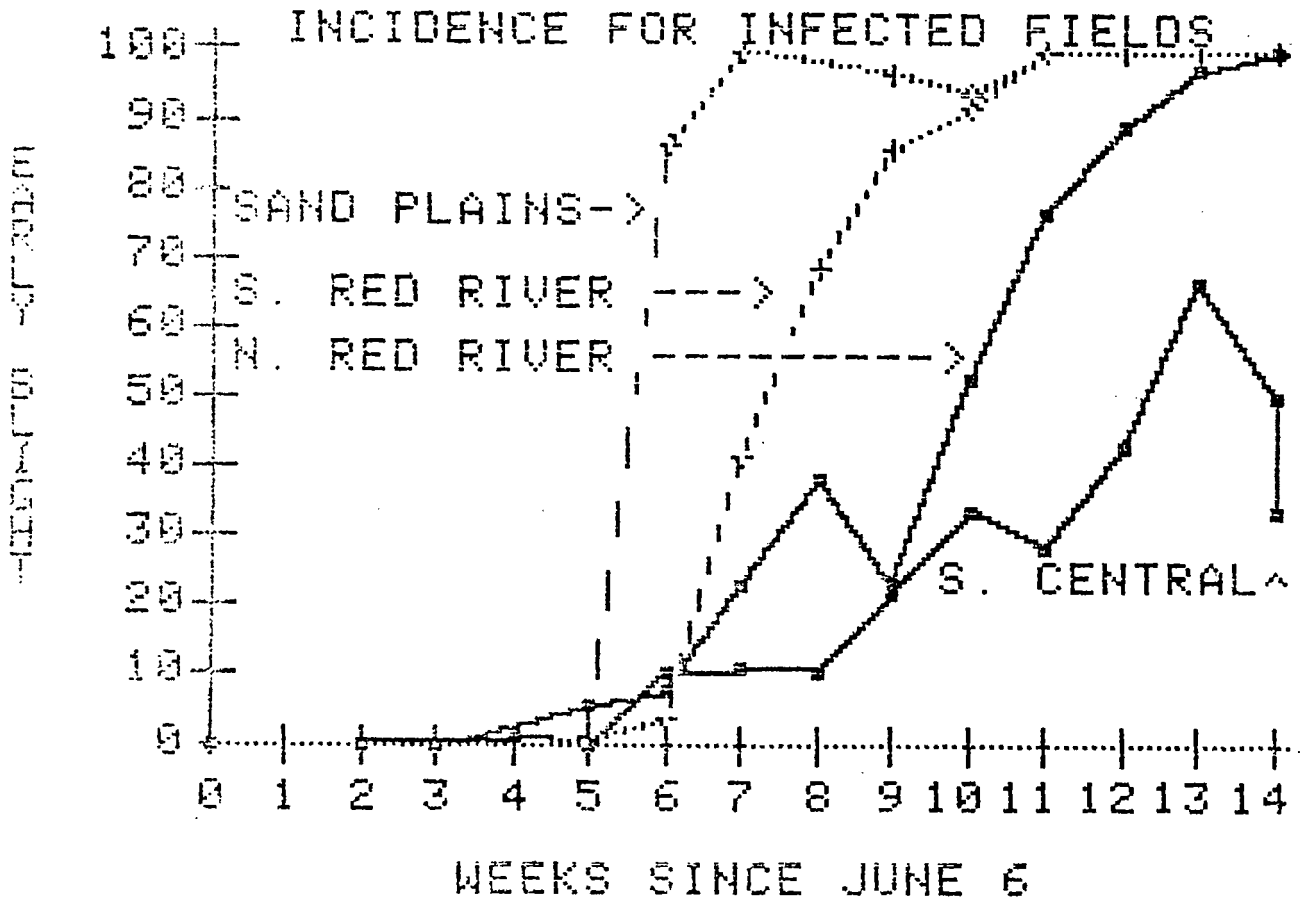
Verticillium wilt is still present in most of the potato fields. This soil-borne disease is causing serious crop loss, both yield and quality. Long range rotations, disease free seed, sanitation and soil fumigations are methods to reduce or control this disease.

The soil fumigation trials scheduled for this fall were abandon because of excessively wet soil conditions. Fumigants should be applied before the soil temperature goes below 50^{o} for best results.

SUNFLOWERS

Mildew and rust were present again this year. Also, white mold and some early dying. The seed treatment fungicide Apron should give good control for seedborne mildew.

FIGURE 1.



For each of the four regions, early blight incidence figures were averaged for each week. Only those fields which at some point in the season had early blight reported are included. That is, if a field did not develop early blight, it is not summarized above.

Note that week 0, for example, corresponds to June 6 - June 12.

FUNGICIDES[1/] FOR USE ON FIELD CROPS

CEREALS

SEED TREATMENT - WHEAT, BARLEY, AND OATS

Common Name	Trade Names	Bunt Control	Seedling Blight Control	Remarks
Captan	Captan Orthocide Evershield (Several other names)		G**	Combination with maneb or zineb for bunt
Captan-HCB	Ortho seed protectant	G	G	
Carboxin	Vitavax			For control of loose smut
Carboxin & Thiram	Vitavax 200 Evershield	F	F	For bunt, seedling blight and loose smut control
Maneb	ABSCO DB Green ABSCO DB Yellow cover-up Granol NM	F	G	DB Green & Granol NM are combined with Lindane
Maneb	Granox NM	G	G	
PCNB	Terra-coat Terra-coat	G G	F F	Combined with Terrozole Combined with Terrozole
Polyram		F	G	
TCMTB	Busan (Cover-up L)	G	F	
Thiram	Arasan-75 Evershield Thiram	F F	G G	

* Seed injury may occur if high moisture seed is treated and stored.

** F = Control Fair
G = Control Good

1/ There may be other seed treatment fungicides on the market that I am not aware of that are also satisfactory for treating cereal seed.

Sugar Beets

Seed Treatment

See Label for Rates & Precautionary Instructions		For Control of Damping-Off				Remarks
		Aphanomyces	Pythium	Phoma	Rhizoctonia	
Captan 35.2%	Slurry	-	-	-	-	General Seed Treatment
Demosan 65W	Slurry	-	G	-	G	May be used as a supplemental treatment
Lesan	Slurry	E	E	P	P	May need 6 oz. on high clay soils, do not exceed 4 oz on light soil.
NOTE: For maximum protection use with a fungicide that controls Rhizoctonia & Phoma. CAUTION: See label for care in handling.						
Maneb 80% Dithane	drillbox	-	G	-	G	
Maneb + Zinc 80% Dithane M-22 Special	drillbox	-	G	-	G	
PCNB + Etirdiazole Terra-coat 1-205	liquid or slurry	G	G	F	E	
Terra-coat SD-205	slurry	G	G	F	E	
Thiram Arasan 50 Red	drillbox or Dust	-	-	G	G	
Arasan 50 Red ND	Dust	-	-	G	G	

P = Poor, F = Fair, G = Good, E = Excellent, - = No data

Powdery Mildew

Fungicides for Powdery Mildew Control	Remarks
Benomyl Benlate	
Sulfur *BIG 8 that is flowable 64% Magnetic 6 flowable 51% That flowable 52% TOP-COP + Sulfur	Apply sulfur if mildew appears by mid-August. One application usually gives adequate protection for 4 weeks.
Copper See listing under cercospora leaf spot	See label for rate and limitations. *Can be used in irrigation systems.

Rhizoctonia and Scab

PCNB - Terraclor emulsifiable concentrate
(Broadcast or in-furrow application)
See label for rates and limitations

Corn

Seed Treatment

Most seed corn is treated prior to delivery. Over treatment with Vitavax 34 is recommended to prevent the introduction of corn Head Smut, by spores on the seed. Treat just shortly before planting.

Eyespot - Rust

Maneb Fungicides

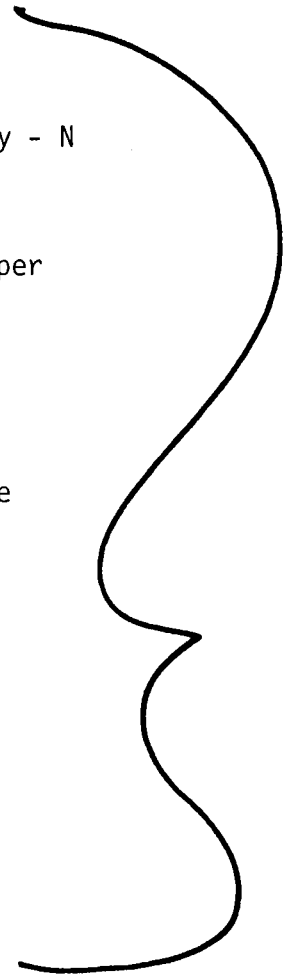
Check label for limitations on use of sweet corn silage. Late planted sweet corn is subject to crop loss by rust.

Potatoes

Seed Piece Treatment	Remarks
Captan Orthocide Plus (Captan + Mertect)	
Maneb Polyram Zineb Dust Treat (Zineb + Streptomycin)	
Late Blight and Early Blight	
Bravo Copper	See label for Rates and Limitations
Kocide 101	
Difolatan Duter (no spreader sticker) Mancozeb	
Dithane M-45 Manzate 200	
Maneb	
Dithane M-22 Manzate	
Zineb Polyram Blight Out (Polyram + Maneb)	
Cereal Leaf Diseases	
Dithane M-45 Manzate 200 Maneb Zineb Kocide 101	Apply by air, using minimum of 5 gallons of water per acre, and spread-sticker per label. See label for rate and limitations.

CERCOSPORA LEAF SPOT

Control requires - early irregular applications, at recommended rates.



Copper

- CITCOP 4E
- CITCOP 6E
- Copper County - N
- Kocide 101
- Kocide 404
- Oxy-Cop 8L
- Tribasic Copper Sulfate

Mancozeb

- Dithane M-45
- Dithane M-45 Flowable
- Manzate-200

Maneb

- Dithane M-22
- Manex

Metiram

- Polyram

Metiram + Maneb

- Blite-Out

Triphenyl Tin Hydroxide

- Duter
- Super Tin

MBC

- Benomyl 50% Benlate
- Thiabendazole 42% Mertect
- Thiophanate-methyl 70% TOPSIN-M

Remarks

For all fungicides use see label for rate and limitations. Do not use less than minimum rate, during favorable conditions of infection the spray schedule may be closed-up. When leaves are wet for 8½ continuous hours, temperatures above 62° (optimum 75°) conditions are favorable for infection.

NOTE: Strains of the Cercospora fungus resistant to these fungicides have been identified. These fungicides are not recommended for use in area where resistant strains occur. They may still be effective in areas where the new strain of Cercospora are not present.

The fungicides in the MBC group are systemic in that the chemical enter into the plant. However, this chemical does not move from old leaves to the new leaves.

HERBICIDES

This is a listing of some herbicides now sold for major crop use in Minnesota. The application rate refers to pounds of active ingredients or acid equivalent per acre on a broadcast basis. The information given is not intended to replace label instructions; follow label instructions closely. Refer to Agricultural Extension Service, University of Minnesota, fact sheets and folders on weed control by crop and to product labels for additional information.

Acifluorfen (Blazer) - Rohm and Haas

Use--Control of many annual broadleaf weeds in soybeans, including eastern black nightshade. A mixture with bentazon (Basagran) is expected to be labeled for use in 1983. This mixture will control more species of weeds than either chemical alone.

Rate of application--3/8 to 1/2 pound per acre.

Time of application--Postemergence; acifluorfen effectively controls most annual broadleaf weeds in soybeans when applied before the weeds exceed the four (4) true-leaf stage. Weeds treated after they exceed the maximum size listed on the herbicide label will not be adequately controlled. Top growth will die, but in most cases regrowth will occur from the roots or lower stems of larger established broadleaf weeds.

Remarks--Rain or irrigation within six (6) hours of application may reduce the effectiveness of acifluorfen. Hot and humid weather increases the effectiveness of acifluorfen. The herbicide should not be applied when recent daytime temperatures are below 70° F.

Acifluorfen may cause minor temporary injury to treated soybean leaves. The injury will appear as a speckled yellowing, and/or a crinkling of the treated leaves. The herbicide does not affect new growth. Actively growing soybeans usually recover quickly.

Formulation--2 pounds per gallon liquid. The 2S formulation includes a surfactant. The 2L formulation does not contain a surfactant. Follow the label instructions for adding a surfactant or oil concentrate.

Alachlor (Lasso, Lasso II) - Monsanto

Use--Annual grass and nutsedge control in corn, dry beans, potatoes and soybeans; some broadleaf control. Use in preemergence mixtures with atrazine, cyanazine, dicamba, simazine, or linuron on corn; with linuron, chlorpropham, bifenox, dinoseb, dinoseb + naptalam, chloramben or metribuzin on soybeans; and preplanting with trifluralin on dry beans. Used in minimum tillage corn with paraquat or glyphosate and atrazine, cyanazine, or simazine. In minimum tillage soybeans with glyphosate or paraquat and metribuzin or linuron.

Rate of application--2 to 4 pounds per acre on corn and soybeans and 2 to 3 pounds per acre on dry beans in the liquid formulation.
--2.4 to 3.9 pounds per acre in the granular formulation on corn or soybeans.

Alachlor (Lasso, Lasso II) (continued)

Time of application--preplanting or preemergence; preplanting preferred for nutsedge control. Can be used with atrazine on corn up to the time corn is 5 inches tall or with dicamba until corn is 3 inches tall and weeds reach the 2-leaf stage. Postemergence treatments should not be applied with fluid fertilizer. Preplanting or preemergence applications may be applied with fertilizer solutions.

Remarks--Research results show good control of annual grasses, nutsedge, pigweed, and fair lambsquarters control. Control of other broadleafs was not consistent. Alachlor alone or with atrazine can be applied with center pivot irrigation for corn. Adzuki beans are very susceptible to injury from alachlor.

Formulation--Lasso--4 pounds per gallon liquid.
Lasso II--15 percent granules.
Lasso + atrazine--9 + 6 percent granules.

Ametryne (Evik) - Ciba-Geigy

Use--Annual weed control in corn.

Rate of application--1-1/2 to 2 pounds per acre.

Time of application--Postemergence directed after corn is at least 12 inches tall. Do not apply later than 3 weeks before tasseling.

Remarks--Care must be taken to avoid contact with corn leaves. A surfactant should be added. This is usually considered an emergency treatment. May be used for wild proso millet control when corn is more than 12 inches tall and millet is less than 4 inches tall.
Formulation--80 percent wettable powder.

Asulam (Asulox) - Rhone-Poulenc

Emergency use--Asulam was granted an emergency (Section 18) label in 5 Northwest Minnesota counties in 1982 to control wild oat and to suppress foxtail and wild buckwheat in flax. CAUTION: As of November 1, 1982, asulam is not cleared for use on flax but label clearance is expected for 1983. The flax variety 'Flor' has been injured by asulam in recent tests and will be restricted on the label.

Rate of application--1-1/4 pounds per acre.

Time of application--Postemergence when the majority of wild oat are in the 3-4 leaf stage.

Remarks--Flax injury may occur if asulam is applied under stress conditions or at other growth stages.

Formulation--3.34 pounds per gallon liquid.

Atrazine (AAtrex and several other trade names) - Ciba-Geigy, Shell and others

Use--Weed control in corn, sorghum, and proso millet. Effective in controlling quackgrass with a fall and/or early spring application followed by plowing. Only corn can be planted following treatment. Used in mixtures with alachlor, linuron, metolachlor, paraquat, simazine or propachlor and with butylate or EPTC plus crop protectant on corn.

Rate of application--(1) Weed control in corn: 1.2 to 3.0 pounds per acre. Use higher rate on fine-textured soils or soils with high organic matter. (2) Weed control in sorghum: 2 to 3 pounds per acre. (3) Quackgrass control: 3 to 4 pounds per acre; a split application of 2 pounds per acre in the fall before plowing and 2 pounds per acre in the spring works best on quackgrass. (4) Weed control in proso millet: 1/2 to 2 pounds per acre.

Time of application for weed control in corn and sorghum--Preemergence or preplant in corn and postemergence in corn and sorghum. If applied postemergence, applications before weeds are 1-1/2 inches tall are more effective than later applications. Atrazine is cleared for use on corn up to layby-stage (about 30 inches tall) of the corn, but weed control is usually not as good on large weeds. Addition of emulsifiable petroleum or vegetable oils has improved performance of postemergence atrazine sprays on corn. Various formulations of surfactants and detergents used with atrazine have not improved weed control as much as the use of oils. Apply preplanting or preemergence for proso millet.

Remarks--Susceptible crops have been injured in rotation following treated crop. To minimize injury to susceptible crops following corn, use the lowest rate consistant with good weed control; use band applications rather than broadcast applications and thoroughly till soil before planting susceptible crops. Cool temperatures can increase the possibility of corn injury. Do not graze or feed treated corn or sorghum for 21 days after postemergence application.

Formulation-80 percent wettable powder, 4 pounds per gallon dispersible liquid, 90 percent water dispersible granule.

Barban (Carbyne) - Velsicol

Use--Control of wild oat in wheat, barley, flax, soybeans, sugarbeets, sunflowers and peas.

Rate of application--1/4 to 3/8 pound per acre on wheat, barley, and flax; 3/4 to 1 pound per acre on sugarbeets; 3/8 pound per acre on sunflowers and soybeans.

Time of application--Postemergence, when most wild oat are in 2-leaf stage (from the time the second leaf first appears until the third leaf first appears). Time of application is critical. Spray peas before the 6-leaf stage, flax before the 12-leaf stage, and within 30 days of emergence of sugarbeets, sunflower, mustard, and soybeans. Sequential applications (2 sprays of barban) each at 1/4 pound per acre may be made to barley and wheat. Make the first application when the majority of the wild oat are in the 2-leaf stage. The second application (if needed) may be made when the second flush of wild oat are in the 2-leaf stage. If the first application is missed, a single application of 1/2 pound per acre may be made in the 2-1/2 to 3-1/2-leaf stage.

Remarks--Flax and small grain injury sometimes occurs; injury on flax has been more severe. Observe feeding restrictions on label. Do not spray when plants are wet with dew or rain. Spray only when crop is actively growing and not under stress.

Formulation--2 pounds per gallon liquid.

Benefin (Balan) - Elanco

Use--Annual grass control in seedling legumes.

Rate of application--1-1/8 to 1-1/2 pounds per acre.

Time of application--Preplanting. (Do not apply after seeding)

Remarks--Must be incorporated into the soil by disking in two different directions before planting. May be mixed with fluid fertilizers.

Formulation--1-1/2 pounds per gallon liquid.

Bentazon (Basagran) - BASF

Use--Control of most annual broadleaf weeds, including hairy nightshade, Canada thistle, and nutsedge in soybeans, corn, dry or succulent edible beans and peas; in a mixture with atrazine for postemergence use in corn; a mixture with acifluorfen (Blazer) is expected to be labelled for use in 1983.

Rate of application--3/4 to 1-1/2 pounds per acre in soybeans and corn; 3/4 to 1 pound per acre in dry and succulent edible beans and peas. Lower rates are for small, susceptible weeds; higher rates are for larger or more tolerant weeds. Oil concentrate at 1 quart/A can be used in all labeled crops except peas when ground application equipment is used.

Time of application--Postemergence--Bentazon is most effective when the weeds are in the 2 to 4 leaf stage. Soybeans, dry beans, snap and green beans usually have the first to second trifoliolate leaf when the weeds are at the correct size for treatment. Corn is tolerant at all stages, but is usually sprayed when corn has 1 to 5 leaves. To improve control of lambsquarters and pigweed in corn, a postemergence mixture of bentazon, atrazine and oil concentrate can be used. Peas may be treated after 3 pairs of leaves (4 nodes) are present. Do not apply to crops growing under stress such as drought, cold weather, or previous herbicide injury. On thistle and nutsedge, treat when the weeds are 8 to 12 inches and apply a second application 10 days after the first. Do not apply more than a total of 2 pounds of bentazon per acre in one crop year.

Remarks--Rain or irrigation within 24 hours after application may reduce the effectiveness of bentazon. Weed control has been more consistent from applications made during the day than from early morning, late evening, or night applications. Applications made when plants are dry are more effective.

Formulation--4 pounds per gallon liquid.

Bifenox (Modown) - Rhone-Poulenc

Use--Control of some annual broad-leaved weeds in soybeans. May be used alone or as a preemergence application after trifluralin, or in a preemergence mixture with alachlor.

Rate of application--1.6 to 2 pounds per acre.

Time of application--Preemergence.

Remarks--Soybean tolerance is limited and malformation and stunting of young soybeans often occur. Grass control has been inconsistent. Do not apply after soybeans start emerging.

Formulation--80 percent wettable powder, 4 pounds per gallon liquid.

Bromoxynil (Brominal, Buctril) - Union Carbide, Rhone-Poulenc

Use--Annual broadleaf control in wheat, barley, oats, rye, flax, and newly planted grasses for sod and seed production. Used in mixture with MCPA ester in wheat, barley, and oats. This mixture may be tank-mixed with diclofop (Hoelon) to control annual grasses and broadleafs in wheat and barley. Clearance is expected for early postemergence use of bromoxynil in corn in 1983.

Rate of application--1/4 to 1/2 pound per acre; 1/4 pound per acre in mixture with MCPA at 1/4 pound per acre.

Time of application--From 2-leaf to early boot stage of wheat, oats, or barley. When flax is 2 to 8 inches tall. Early applications more effective on weeds. Do not treat flax in humid weather or when temperature is over 80°F.

Remarks--Controls wild buckwheat and smartweed better than MCPA or 2,4-D. Does not control perennials. Injures legumes. Some small grain injury has occurred at higher rates.

Formulation--2 or 4 pounds per gallon liquid. Formulations of 2 or 3 pounds per gallon of bromoxymil + 2 or 3 pounds per gallon of MCPA ester are available (Brominal Plus, Brominal 3+3, Bronate).

Butylate (Sutan +) - Stauffer

Use--Control of annual grasses and nutsedge in corn. Used in mixtures with atrazine or cyanazine for annual grass and broadleaf control. A three-way mixture with atrazine and cyanazine is labeled.

Rate of application--3 to 6 pounds per acre.

Time of application--Preplanting, fall preplanting between October 1 and November 15.

Remarks--Must be incorporated into the soil. Proper incorporation can be accomplished by disking field twice, once in each direction, immediately after applying chemical. Sutan + contains a chemical additive to prevent corn injury. Can be applied alone or with atrazine or cyanazine with dry bulk or fluid fertilizer. Sutan + is labeled for use in center pivot irrigation systems.

Formulation--6.7 pounds per gallon liquid, 10 percent granular, 4.8 pounds butylate plus].2 pounds atrazine per gallon liquid (Sutazine).

Chloramben (Amiben) - Union Carbide

Use--Preplanting and preemergence control of annual broadleaf weeds and annual grasses in soybeans, sunflowers, and dry edible beans, including adzuki beans. Postemergence applications can be made to soybeans up to the second trifoliolate leaf stage. Chloramben is labeled for tank mixing with trifluralin, fluchloralin, pendimethalin, vernolate, linuron, alachlor, dinoseb, metribuzin, metolachlor, and 2,4-DB.

Rate of application--1.8 to 2.7 pounds per acre preplanting on preemergence; 2-1/4 to 2.7 pounds per acre postemergence. For wild proso millet control, chloramben may be applied preplant incorporated at 1.8 to 2.7 lb/A followed by a postemergence application of 1.8 to 2.7 lb/A, when soybeans are in the cotyledon to second trifoliolate stage, but before emergence of wild proso millet.

Time of application--Preemergence, preplant incorporated or on soybeans, up to the second trifoliolate leaf stage of soybeans.

Remarks--Chloramben must be moved into the soil by rainfall or incorporated before weeds sprout to be effective. Incorporated treatments result in improved weed control under dry conditions, however, preemergence applications are more effective when rainfall occurs soon after application. Excessive moisture may leach chloramben below the zone of weed seed germination. This is particularly true in coarse textured (sandy) soils. Chloramben may be applied early postemergence from the cracking to second trifoliolate stage of soybeans.

Early stunting of soybeans has been observed under some conditions, but the crop usually outgrows the injury. Chloramben is cleared for use on corn at 0.9 to 1.8 pounds per acre, but experiment station tests showed a definite injury potential to corn and erratic weed control at these rates. Severe stunting of corn occurred in some fields following heavy rains.

Formulation--1.8 pounds per gallon liquid; 10 percent granule; 75 percent DS (dry soluble)

Chlorpropham (Furloe) - PPG

Use--Annual smartweed control in soybeans.

Rate of application--2 to 3 pounds per acre.

Time of application--Preemergence or preplanting.

Remarks--May be used preplanting in mixtures with alachlor, paraquat, profluralin, trifluralin, or vernolate. Does not control weeds other than annual smartweed.

Formulation--4 pounds per gallon liquid.

Chlorsulfuron (Glean) - DuPont

Use--Control of most broadleaf and several grass weeds in wheat and barley.

Time of application--Preemergence or postemergence, but early postemergence use of chlorsulfuron plus a surfactant appears to be the most effective method of application in Minnesota.

Remarks--Chlorsulfuron is a very active herbicide. Rates of 1/8 to 1/2 ounce/A of the 75 percent dry flowable formulation are effective in controlling many common small grain weeds. Chlorsulfuron may persist in high pH soils and cause injury to broadleaf crops following in the rotation. Chlorsulfuron is not labeled for use in soils with a pH above 7.5. Some crops require a 48 month interval after chlorsulfuron use. See label before using.

Formulation--75 percent dry flowable, water dispersible, granule.

Cyanazine (Bladex) - Shell

Use--Annual grass and broadleaf control in corn. Preemergence with atrazine, paraquat, propachlor (Bexton), metolachlor (Dual), or alachlor (Lasso). Preplanting with alachlor (Lasso), metolachlor (Dual), butylate (Sutan +), or EPTC (Eradicane). Used for minimum tillage corn with paraquat. Used preemergence on grain sorghum in mixtures with propachlor.

Rate of application--2 to 4 pounds per acre depending on soil texture and organic matter, 1 to 2.2 pounds per acre with alachlor, 0.8 to 2 pounds per acre with butlyate, 1-1/2 to 2 pounds per acre with EPTC (Eradicane), 0.8 to 2.5 with metolachlor.

Time of application--Preplanting, preemergence, or postemergence on corn through the 4-leaf stage and before weeds exceed 1-1/2 inches. For postemergence, use only the 80 percent wettable powder, not the 4 pounds per gallon liquid dispersible formulation.

Remarks--Do not add petroleum oils to postemergence applications or severe corn injury may result. When applied postemergence under droughty or arid conditions, certain surfactants or emulsifiable vegetable oils may be used with the wettable powder formulation, but under moist conditions, these additives may cause severe corn injury. Can be applied preemergence with fluid fertilizer or through center pivot irrigation systems. Cool temperatures, rain, or dew can increase potential for injury.

Formulation--80 percent wettable powder, 4 pounds per gallon dispersible liquid, 15 percent granule.

Cycloate (Ro-neet) - Stauffer

Use--Annual grass, nutsedge, and broadleaf control in sugarbeets.

Rate of application--3 to 4 pounds per acre.

Time of application--Preplanting; fall or spring.

Remarks--Must be incorporated immediately and thoroughly, tillage tool should be operated 4 to 6 inches deep to incorporate to a depth of 2 to 3 inches.

Formulation--6 pounds per gallon liquid, 10 percent granules.

2,4-D - (Various trade names and manufacturers)

Use--Broadleaved weed control in corn, small grains, and grass pastures.

Rate of application--Corn and small grains: 1/6 to 1 pound per acre depending on formulation used, method of application, the size and kinds of weeds, weather conditions, and stage of crop growth. See label. Grass pastures: 1 to 2 pounds per acre depending on kind of weeds to be controlled.

Time of application--Postemergence. Corn--4 inches to tasseling or after dough stage. Use drop nozzles after corn is 8 inches tall. Wheat and barley--5th leaf to early boot; oats--6th leaf to early boot; pastures--spring or fall when weeds are actively growing.

Remarks--Do not graze dairy cattle for 7 to 14 days after treatment of pastures with 2,4-D (see label).

Formulation--Liquids of various concentrations.

Dalapon (Dowpon M,Dalapon-85) - Dow

Use--Grass control in flax and sugarbeets. Quackgrass control in the fall before planting corn, potatoes, dry beans, or sugarbeets in the spring.

Rate of application--(1) Flax: 3/4 pound per acre. May be tank-mixed with 1/4 pound per acre of MCPA on flax. (2) Sugarbeets: 2 to 3-1/2 pounds per acre. (3) 6 to 11 pounds per acre for fall quackgrass control.

Time of application--(1) Flax and sugarbeets: when grasses are not more than 2 inches tall. Postemergence until sugarbeets reach 6-leaf stage, directed from 7-leaf stage until beets are 14 inches. (2) For quackgrass control, apply on growing quackgrass; plow 10 days later.

Remarks--Adding a surfactant to the dalapon spray mix improves wetting and improves grass control.

Formulation--74 percent water soluble powder.

2,4-DB (Butoxone, Butyrac 200) - Rhone-Poulenc, Union Carbide

Use--Broadleaved weed control in seedling stands of alfalfa, birdsfoot trefoil, and clovers and established stands of alfalfa. Cocklebur control in soybeans.

2,4-DB is labeled for postemergence use with naptalam and as directed sprays with linuron and metribuzin.

Rate of application--1/2 to 1-1/2 pounds amine and 1/2 to 1 pound ester per acre on forage legumes. 1/5 pound amine per acre on soybeans.

Time of application--Postemergence when seedling legumes have 1 to 4 trifoliolate leaves and weeds less than 3 inches tall or on established legumes in the fall when weeds are less than 3 inches tall. For cocklebur control in soybeans, apply as a directed spray when soybeans are 8 to 12 inches high and cocklebur no more than 3 inches tall.

Remarks--Do not spray drought stressed soybeans or soybeans that show symptoms of phytophthora root rot disease. Do not apply when extreme temperatures are expected within 2 to 3 days. Observe grazing and time of harvest precautions on the label.

Formulation--1.75 or 2 pounds per gallon liquid.

Desmedipham (Betanex), Desmedipham + Phenmedipham (Betamix) - Nor-Am

Use--Annual grass and broadleaf control in sugarbeets, less effective on grasses. Desmedipham is more effective on redroot pigweed than the mixture of desmedipham + phenmedipham. Both formulations were available in limited quantities on an experimental use permit for wild mustard control in sunflowers during 1982. This EUP may be extended or a special local need or emergency use label may be sought for 1983.

Rate of application--1 to 1-1/4 pounds per acre of total active ingredient.

Time of application--Early postemergence after sugarbeets have four true leaves. Weeds should not have more than four true leaves for best control.

Remarks--Applications of desmedipham and phenmedipham following preplanting EPTC or preemergence TCA have sometimes resulted in sugarbeet injury. To reduce injury do not use more than 1 pound per acre where preplanting or preemergence herbicides have been used and do not apply if highest temperature expected during the day exceeds 85°F. If temperatures are approaching this limit, application in the late afternoon will decrease injury potential. Split applications (use of a half-rate followed in 5 to 7 days by a second half rate) have reduced sugarbeet injury and improved weed control compared to a single application at the full rate. Rainfall within 6 hours after spraying may reduce weed control.

Formulation--1.3 pounds per gallon liquid.

Diallate (Avadex) - Monsanto

Use--Control of wild oat in alfalfa, barley, flax, sugarbeets, potatoes, soybeans, forage legumes, corn, lentils, and peas.

Rate of application--1-1/4 pounds per acre on barley; 1-1/2 to 2 pounds per acre on other crops.

Time of application--Preplanting on flax or sugarbeets; postseeding (preemergence) on barley. Fall application is a possibility before sugarbeets. Granules may be used in fall, but are not recommended for spring.

Remarks--Quite volatile and must be incorporated soon after application. Incorporate preplanting applications with disk, cultivator, or harrow to a depth of 2 inches. In postseeding applications, incorporate chemical with two harrowings at right angles. Small grain injury has been observed, particularly with preplanting application. Do not apply to field in ridged condition. This chemical irritates skin and eyes; use caution when handling. Diallate may persist in the soil enough to affect tame oats planted the next year.

Formulation--4 pounds per gallon liquid, 10 percent granules.

Dicamba (Banvel, Banvel II) - Velsicol

Use-Postemergence control of most broadleaved weeds except wild mustard in wheat, oats, corn, and grass pastures. Especially useful for controlling wild buckwheat and smartweed in wheat and oats. Can be used preemergence with alachlor or metolachlor, or as an overlay treatment until corn is 5 inches tall following butylate, EPTC +, alachlor, metolachlor, propachlor, atrazine, cyanazine or pendimethalin. May be applied postemergence on corn with 2,4-D or atrazine. No oil or surfactants should be added to postemergence applications.

Rate of application--1/8 pound per acre with MCPA at 1/4 pound per acre in wheat and oats; 1/4 to 1/2 pound per acre alone or with 2,4-D in corn; 1/4 to 8 pounds per acre in grass pastures; 1/4 to 1/2 pound per acre with alachlor preemergence on corn.

Time of application--From 2- to 5-leaf stage of wheat and oats. Up to time corn is 2 feet tall and not within 15 days of tasseling. Application made too close to tasseling can cause barren ears. When perennial broadleaf weeds are 8 to 12 inches tall and up to bud stage in grass pastures.

Remarks--Can be combined with MCPA in wheat and oats or with 2,4-D in corn for control of mustard and other broad-leaved weeds. If used on pastures, observe grazing restrictions on label. Do not mix additives with dicamba or crop injury may result. Do not apply preemergence on sandy soils or soils with less than 2 percent organic matter. Avoid drift to nearby susceptible broadleaf crops. Considerable drift injury has occurred on soybeans. To prevent drift, follow the application instructions on the label. Apply in 20 gallons or more water per acre; set pressure at 20 psi or less; do not apply to corn when soybeans in the area are over 10 inches tall; do not use on a day the temperature is expected to be over 85°F.; apply when wind is less than 5 mph; do not apply after corn is 2 feet tall.

Formulation--2 or 4 pounds per gallon liquid; 5 percent granules; commercial combinations with MCPA and 2,4-D are available.

Diclofop (Hoelon) - American Hoechst

Use--Annual grass control in soybeans wheat and barley, including wild oat and volunteer corn.

Rate--3/4 to 1-1/4 pounds per acre for wheat and soybeans
--3/4 to 1 pound per acre for barley

Time of application--Diclofop effectively controls many annual grasses including wild oat and volunteer corn in fall and spring seeded wheat, spring seeded barley, and soybeans. Annual grasses including wild oat can be controlled with diclofop up to the 4-leaf stage. Use 1-1/4 pounds of diclofop per acre when the weeds have 3 to 4-leaves, lower rates when the weeds have 3 or fewer leaves. Treat yellow foxtail and crabgrass before they reach the 3 leaf stage. Volunteer corn should be treated after the corn plants have emerged, but before the tallest corn plants exceed 10 inches in height.

The time of diclofop application also depends on the crop. Fall and spring seeded wheat should not be treated after the 4 leaf-stage. Spring seeded barley should not be treated after the 3-leaf stage. Injury may result from applications made after the crop exceeds the maximum labeled leaf stage. Soybeans should be treated before the formation of the sixth trifoliolate leaf.

Remarks--Diclofop is most effective when applied to weeds that are growing rapidly. Weed control may be reduced if treatment is made under dry soil conditions, or when weather conditions are otherwise not favorable for rapid growth.

Do NOT tankmix diclofop with any other pesticide (except for bromoxynil), and do NOT apply diclofop within 7 days of the application of another pesticide. The presence of another pesticide in the tank or on the leaves of treated weeds may reduce the effectiveness of diclofop. Do not apply more than one application of diclofop in a growing season.

Diclofop is a restricted-use pesticide and can be applied only by a certified applicator. Adhere to ALL label requirements concerning safe handling and use of this herbicide.

Formulation--3 pounds per gallon liquid.

Diethatyl (Antor)

Use--Control of pigweed and some annual grasses in sugarbeets.

Rate of application--4 to 6 pounds per acre.

Rate of application--Preplanting incorporation.

Remarks--Shallow incorporation (1 to 2 inch) gives best results.

Formulation--4 lbs. per gallon liquid.

Difenzoquat (Avenge) - American Cyanamid

Use--Controls wild oat in barley, winter wheat, Era, Butte, Kitt, Olaf and Fortuna spring wheat, and all varieties of durum wheat except Lakota, Wascana, Vic and Edmore. Significant injury can occur from the use of difenzoquat on some spring wheat varieties including Alex, Bonanza, Bounty, Lark, Len, Waldron and others.

Rate of application--5/8 to 1 pound per acre depending on density of wild oat population (see label).

Time of application--Postemergence when majority of wild oat plants are in the 3- to 5-leaf stage of growth.

Remarks--Difenzoquat may be tank-mixed with 2,4-D or MCPA amine or ester, bromoxynil or a mixture of MCPA and bromoxynil. Do not apply mixture of difenzoquat and 2,4-D until the crop is 6 inches tall or until after the crop is well tillered. Apply difenzoquat in 5 to 20 gallons of water per acre by ground equipment or 3 to 10 gallons of water per acre by aircraft, but use a surfactant when applying over 10 gallons of water per acre. Do not apply before a rain or when plants are wet from dew or rain and do not make more than one application per season. Do not graze treated fields or cut treated forage for silage.

Formulation--2 pounds per gallon liquid.

Dinoseb (Premerge and others) - Dow

Use--Control of annual weeds in dry beans, corn, forage legumes, small grains, and soybeans. In preemergence mixture with alachlor (Lasso) or chloramben (Amiben) on soybeans.

Rate of application--Varies with crop, soil type, and temperature. See label.

Time of application--Preemergence and/or postemergence depending on crop. Follow label instructions closely.

Remarks--Results vary with soil and temperature conditions. Crop injury may occur.

Formulation--Liquids of various concentrations.

Endothall (Endothal, Herbicide 273) - Pennwalt

Use--Control of annual smartweed, wild buckwheat, and marshelder in sugarbeets.

Rate of application--3/4 to 1-1/2 pounds per acre.

Time of application--Postemergence when sugarbeets have 4 to 6 leaves.

Remarks--Excessive injury, especially to very small sugarbeets, may occur if temperatures are above 80° F. Poor weed control may result at temperatures below 60° F.

Formulation--3 pounds per gallon liquid and 5 percent granular.

EPTC (Eptam); EPTC Plus Crop Protectant (Eradicane); EPTC plus crop protectant plus extender (Eradicane Extra) - Stauffer

Use--EPTC: Control of annual grasses, nutsedge and some broadleafs in sugarbeets,

potatoes, seedling alfalfa, birdsfoot trefoil, clovers, sunflowers, flax, and dry edible beans except adzuki beans. EPTC can be mixed with trifluralin (Treflan) on dry beans. "Eradicane" or "Eradicane Extra" can be used in corn, especially for nutsedge, wild proso millet; gives some quackgrass control. Eradicane can be used in mixtures or as a three-way combination with atrazine and cyanazine on corn and Eptam may be mixed with trifluralin or fluchloralin on dry beans and sunflowers, and with chloramben on sunflowers (except that mixtures with fluchloralin should not be used on adzuki beans).

Rate of application--EPTC: 2 to 3 pounds per acre on sugarbeets spring applications or 4 to 4-1/2 pounds per acre for fall applications; 3 pounds per acre on seedling legumes, sunflowers, flax (fall application only) and dry edible beans; Eradicane or Eradicane Extra: 3 to 6 pounds per acre in corn.

Time of application--Preplanting.

Remarks--Must be incorporated immediately to avoid loss of chemical by volatility. Eradicane and Eptam can be applied with dry bulk and liquid fertilizers or through center pivot irrigation. Perennial grasses must be turned under and chopped thoroughly prior to treatment.

Formulation--Eptam: 7 pounds per gallon liquid; 10 percent granular; Eradicane: 6.7 pounds per gallon liquid; Eradicane Extra: 6 pounds per gallon liquid.

Ethofumesate (Nortron) - Fisons

Use--Control of some annual broadleafs and grassy weeds in sugarbeets. Use in mixtures with TCA or as a preemergence application following fall application of EPTC.

Rate of application--1.12 to 3.75 pounds per acre.

Time of application--Preplanting, preemergence, or postemergence.

Remarks--Incorporation has improved weed control. Soil residues may affect wheat, barley, and oats the following year. Sugarbeet injury may occur, especially on coarse-textured soils if used in combination with cycloate or EPTC, or if used postemergence in combination with desmedipham and phenmedipham.

Formulation--1-1/2 pounds per gallon liquid and 4 pounds per gallon dispersible liquid.

Fluazifop (Fusilade) - ICI

Label clearance for soybeans is expected for the 1983 crop season.

Use--Control of grassy weeds in soybeans.

Time of application--Early postemergence.

Remarks--Fluazifop has given excellent control of most annual grasses including volunteer corn, foxtails, wild proso millet and woolly cupgrass in soybeans. The chemical also controls perennial grasses. An oil concentrate is used with the spray mixture.

Formulation--4 pounds per gallon liquid.

Fluchloralin (Basalin) - BASF

Use--Annual grass, pigweed, and common lambsquarters control in soybeans, sunflowers, and most dry edible beans except adzukis. Labeled for tank-mix with metribuzin in soybeans. Can be tank-mixed with EPTC (Eptam) for most dry beans except adzukis and flat-podded beans.

Rate of application--1/2 to 1-1/2 pounds per acre, depending on soil type.

Time of application--Preplant incorporated.

Remarks--Fluchloralin must be mixed thoroughly with the top 1 to 2 inches of soil for optimum results. This can be effectively accomplished by incorporating the herbicide twice with a disk or similar implement. The second incorporation should be carried out at a right angle (90 degrees) to the direction of the first incorporation for best results. Fluchloralin must be incorporated at least once within 8 hours of application to prevent herbicide loss from the soil surface. May be applied with liquid or dry fertilizers.

Formulation--4 pounds per gallon liquid.

Glyphosate (Roundup) - Monsanto

Use--Non-selective control of many annual and perennial weeds before planting alfalfa, edible beans, peas, barley, corn, forage legumes and grasses, oats, potatoes, sorghum, soybeans, sugarbeets, wheat, and many vegetable crops. Spot treatment of weeds in these same crops after crop emergence, but crop will be killed or severely injured. May also be used in minimum tillage systems as tank mixtures with alachlor, metolachlor, atrazine, linuron, simazine, metribuzin, and cyanazine.

Rate of application--3/4 to 3 pounds per acre depending on time of application and weed species (see label).

Time of application--In the fall or spring before crops are planted. See label for proper timing on each weed species. Apply to actively growing foliage.

Quackgrass and wirestem muhly--when grass is at least 8 inches tall (3 or 4 leaf stage) and actively growing.

Canada thistle--bud stage in spring or before frost in fall.

Field bindweed--at or beyond full bloom.

Common milkweed--late bud to flower stage.

Can be applied with recirculating sprayers, roller or pipe-wick applicators in soybeans. Volunteer corn control has been acceptable with all of these applicators.

Remarks--Take extreme care when using this product to avoid drift since most plants are susceptible to injury.

Formulation--3 pounds acid equivalent per gallon liquid.

Hexazinone (Velpar) - DuPont

Use--Weed control in established alfalfa.

Rate of application--0.45 to 1.35 pounds per acre. Use the lower rates (0.45 to 0.90 pounds per acre) on coarse textured soils low in organic matter and the higher rates (0.90 to 1.35 pounds per acre) for medium and fine textured soils and soils high in organic matter.

Time of application--In the fall after alfalfa becomes dormant or in the spring before new growth begins.

Remarks--Treat only stands of alfalfa established for one year or more. Do not use on seedling alfalfa or on alfalfa-grass mixtures or other mixed stands. Hexazinone may injure alfalfa if excessive rates or overlaps occur. Also injury may result from the occurrence of excessive rainfall or too much irrigation water within a week or two after application.

Formulation--90 percent water soluble powder.

Linuron (Lorox) - DuPont

Use--Preemergence weed control in corn, sorghum and soybeans and directed postemergence in corn. Used in mixtures with atrazine, alachlor, glyphosate, paraquat, or propachlor preemergence on corn and with alachlor, chloramben, metolachlor, glyphosate or paraquat preemergence on soybeans.

Rate of application--(1) Corn: 1/2 to 1-1/2 pounds per acre preemergence in combination with equal rates of atrazine active ingredient or with 3 pounds per acre of propachlor or with 1-1/2 to 3 pounds per acre of alachlor; 1-1/2 pounds per acre with wetting agent in postemergence directed spray applications. (2) Soybeans: 1/2 to 2-1/2 pounds per acre; (rate differs with soil types) or 1/2 to 1-1/2 pounds per acre with 1-1/2 to 3 pounds per acre of alachlor or preemergence over preplanting trifluralin.

Time of application--(1) Corn: preemergence or directed spray postemergence when corn is at least 12-18 inches tall and weeds are 8 inches or less in height. (2) Soybeans: preemergence.

Remarks--Use in postemergence directed spray applications does not eliminate early season competition between weeds and corn. This early competition can reduce yields. Linuron has caused injury (stand reduction and stunting) to corn and soybeans in some Minnesota trials, particularly on sandy soils. On corn, do not apply linuron within 60 days of harvest.

Formulation--50 percent wettable powder, 4 pounds per gallon dispersible liquid.

MCPA (Various trade names and manufacturers)

Use--Broadleaved weed control in small grains, flax, and pastures.

Rate of application--Small grains: 1/6 to 2/3 pounds per acre depending on formulation used, size and kinds of weeds, weather conditions, and stage of crop growth. Flax: 1/4 pound per acre. May be tank-mixed with dalapon on flax at 1/4 pound per acre plus 3/4 pound per acre of dalapon. Grass pastures: 1/2 to 2 pounds per acre depending on weed susceptibility. See label.

Time of application--Postemergence. Small grains--two leaves to early boot; flax--2 to 6 inches. In pastures, when perennial weeds are 6 to 8 inches tall or in the rosette stage and actively growing.

Formulation--Liquids of various concentration.

Metolachlor (Dual) - Ciba-Geigy

Use--Control of annual grasses, pigweed, and nutsedge in corn, soybeans, dry beans and potatoes. Used in mixtures with atrazine, cyanazine, simazine, or dicamba in corn or with metribuzin, linuron, naptalam + dinoseb, chloramben, chlorpropham, trifluralin or dinoseb in soybeans. For minimum tillage corn in mixtures with glyphosate, paraquat, atrazine, or simazine and for soybeans with linuron, metribuzin, glyphosate or paraquat.

Rate of application--1-1/2 to 3 pounds per acre.

Time of application--Preplanting, incorporated; preemergence; or early post-emergence alone or with atrazine when weeds are in 2-leaf stage and corn is less than 5 inches tall.

Remarks--Metolachlor can be applied with fluid fertilizer or with center pivot irrigation systems.

Formulation--8 pounds per gallon liquid. Metolachlor plus atrazine (Bicep) 2-1/2 plus 2 pounds per gallon dispersible liquid.

Metribuzin (Lexone, Sencor) - DuPont, Mobay

Use--Annual weed control in soybeans. Control of certain annuals, winter annuals, and biennials in established alfalfa or alfalfa-grass mixtures. Better on broadleafs than grasses. Can be used on soybeans in mixtures with

alachlor, metolachlor, chloramben, glyphosate, paraquat, trifluralin, fluchloralin, or pendimethalin.

Rate of application--Soybeans: 3/8 to 7/8 pound per acre depending on soil texture and organic matter. 1/8 to 3/4 pound per acre in mixtures. Alfalfa (established one year or more): 3/8 to 1 pound per acre depending on soil texture and kinds of weeds present.

Time of application--Soybeans: Preplanting, preemergence or a combination of preplanting and preemergence. Alfalfa: When alfalfa is dormant, spring or fall.

Remarks--Soybeans: Early soybean stunting and necrosis have frequently occurred with this chemical. Consult the label for restrictions for use on various soil types. Soybean injury may occur on coarse-textured soils low in organic matter. Crop injury may occur on calcareous soils or alkaline soils with a pH over 7.5 or in conjunction with soil applied organic phosphate pesticides. Certain soybean varieties, Tracy and Altona, are susceptible to injury. Alfalfa: May be used to control perennial grasses in alfalfa. Lower rates will suppress grasses. Higher rates will severely reduce forage grass stands. Do not graze or harvest alfalfa within 28 days of treatment. Metribuzin may be applied on dry fertilizers or with liquid fertilizers.

Formulation--50 percent wettable powder, 75 percent "dry flowable granule," 4 pounds per gallon dispersible liquid.

Naptalam (Alanap-L) - Uniroyal

Use--Postemergence control of annual broad-leaved weeds (cocklebur, giant ragweed, volunteer sunflower, wild mustard) in soybeans. Used in combination with 2,4-DB.

Rate of application--1 to 1-1/2 pounds per acre of naptalam plus 3/64 to 1/16 pound per acre of 2,4-DB. Use a nonionic surfactant with the mixture.

Time of application--When soybeans are about 18 inches tall (7-10 days before bloom through mid-bloom).

Remarks--This treatment is primarily to control large (12 inches) broadleaved weeds that have escaped earlier control. There is some risk of soybean injury. Do not apply to drought stressed soybeans. Rain within 6 hours after application will reduce effectiveness.

Formulation--2 pounds per gallon liquid.

Naptalam + dinoseb (Dyanap) - Uniroyal

Use--Preemergence and postemergence control of some annual broadleafs and grasses in soybeans. May be used alone, with alachlor (Lasso) or metolachlor preemergence.

Rate of application--Preemergence: 2 to 4 pounds of naptalam plus 1 to 2 pounds of dinoseb per acre alone or with 2 pounds of alachlor. Rates vary

with soil type. Postemergence: 1/2 to 1 pound of naptalam plus 1 to 2 pounds of dinoseb per acre.

Time of application--Preemergence up to emergence of soybeans when used alone or preemergence with alachlor or metolachlor. Postemergence after soybeans have the second trifoliolate leaf up to when soybeans are 20 inches tall.

Remarks--Preemergence application may cause crop injury, especially if heavy rains occur or on sandy soils. Postemergence treatment may injure crop when temperatures are high or if improperly applied. Follow application and rate instructions on the labels.

Formulation--2 pounds naptalam and 1 pound dinoseb per gallon liquid.

Oxyfluorfen (Goal) - Rohm and Haas

Use--Control of some annual broad-leaved weeds in no-till soybeans only. May be used alone, as a preemergence application after trifluralin or in a preemergence mixture with alachlor.

Rate of application--1/4 to 3/8 pounds per acre.

Time of application--Preemergence.

Remarks--Soybean tolerance is limited. Malformation and stunting of young soybeans often occurs, especially under wet, cool conditions. Do not apply after soybeans start emerging. Do not use on muck or peat soils or on conventionally tilled soils.

Formulation--2 pounds per gallon liquid.

Paraquat (Paraquat, Gramoxone) - Chevron, ICI

Use--Paraquat is a contact herbicide for killing vegetation before planting or before crops emerge, and as a desiccant for weeds in soybeans and sunflowers (oil seed varieties only). A special local needs registration is also available in Minnesota for postharvest desiccation of Kentucky bluegrass fields to facilitate burning.

Rate of application--1/8 to 1 pound per acre depending on use and crop. Use X-77 spreader with paraquat.

Time of application--Apply paraquat before planting or before the crop emerges for seedling weed control in minimum and no-till cropping situations. As a preharvest desiccant, paraquat is applied after the crop is physiologically mature. In soybeans, application should be made when the beans are fully developed, at least 1/2 of the leaves have dropped, and the leaves left on the plant are turning yellow or when the soybean seeds are at 30 percent moisture or less. In sunflowers, application should be made when the seed is at 35 percent moisture or less. Sunflower head color is no longer considered a good indicator of maturity.

Remarks--Paraquat kills growing annual weed seedlings, but only the top growth of perennials. Paraquat is highly toxic and has a "restricted use" classification (can be applied only by a certified applicator). A small amount could be fatal if swallowed. Avoid contact with the eyes or skin and do not breathe the spray mist. Follow precautions on the label.

Formulation--2 pounds per gallon liquid.

Pendimethalin (Prowl) - American Cyanamid

Use--Preemergence control of annual grasses and some annual broadleaved weeds in corn. Can use alone or in a mixture with atrazine, cyanazine (Bladex), or dicamba (Banvel) for broader spectrum weed control in corn. Preplanting incorporated or preemergence in soybeans alone or in mixtures with metribuzin, chloramben, and linuron. Preplanting incorporated alone or with chloramben on sunflowers.

Rate of application--1/2 to 2 pounds per acre for corn; 1/2 to 1-1/2 pounds per acre for soybeans; 1/2 to 1-1/2 pounds per acre for sunflowers.

Time of application--Preemergence or early postemergence, up to 2-leaf stage of corn and weeds up to 1 inch tall, with atrazine or cyanazine in corn; preemergence or preplanting in soybeans; pendimethalin alone or mixed with atrazine may be applied postemergence incorporated on corn from 4 inches tall to last cultivation; preplant incorporated on sunflowers.

Remarks--Do not use on soils containing less than 1-1/2 percent organic matter, nor on peat or muck. There is crop injury potential on soils with lower organic matter and sandy soils. Weed control has not been consistent on clay soils, peat and muck. Do not drag corn fields before crop emerges and do not incorporate on corn fields. On soybeans and sunflowers, incorporate 1 to 2 inches deep. Can be used with liquid fertilizer.

Formulation--4 pounds per gallon liquid.

Picloram (Tordon) - Dow

Use--One formulation (Tordon 22K) is cleared for use in a tank-mix combination with 2,4-D amine or ester or MCPA amine for control of certain broadleaf weeds in spring and winter wheat and barley. All formulations may be used on non-cropland, except do not use near rivers, lakes or other water supplies. Two formulations (Tordon 22K and Tordon 2K) may be used on grass pastures in Minnesota on a special local need label.

Rate of application--A tank-mix combination of 1/4 ounce picloram (1 fluid ounce of Tordon 22K) and 1/4 pound 2,4-D amine or ester or MCPA amine for wheat and barley, 1/2 to 2 pounds per acre in grass pastures.

Time of application--Postemergence, when wheat or barley is in the 4 to 6-leaf stage and weeds are small; postemergence in grass pastures when perennial broadleaf weeds are 6 to 8 inches tall but before bloom.

Remarks--A higher rate of application, 3/8 ounce per acre of picloram and 3/8 pound per acre of 2,4-D amine or ester or MCPA amine is cleared for use in the same crops when weeds are more advanced or under dry conditions. This higher rate may be applied from the 6-leaf stage to early boot stage. Apply picloram only on small grain fields that will be fallowed or replanted to a grass or grain crop the following year. Do not use on small grain to be underseeded to a legume. Do not use on sandy soils where ground water level is within 10 feet of the soil surface. Picloram is a restricted use pesticide and can be applied only by a certified applicator. Adhere to all label requirements for safe use of this herbicide.

Formulation--(Tordon 22K) 2 pounds per gallon liquid.

Propachlor (Ramrod) - Monsanto

Use--Annual grass control in soybeans grown for seed, corn, and grain sorghum. Used in mixtures with atrazine or cyanazine or linuron on corn and with atrazine, cyanazine, or propazine on sorghum.

Rate of application--3 to 6 pounds per acre.

Time of application--Preemergence.

Remarks--Propachlor is cleared to use on corn for grain, seed or forage, but on soybeans for seed only. Do not use propachlor-treated soybeans for food, feed, or oil. Can be used with liquid fertilizer.

Formulation--65 percent wettable powder; 20 percent granular, 4 pounds per gallon dispersible liquid, or Ramrod/atrazine, 48 + 21 percent wettable powder, 3 + 1 pounds per gallon flowable.

Propanil (Stampede) - Rohm and Haas

Use--Control of green and yellow foxtail and specific broadleaf weeds in hard red spring and durum wheat.

Rate of application--1-1/2 pounds per acre alone or 1-1/8 pounds per acre in combination with 1/4 pound per acre of an iso-octyl ester formulation of MCPA.

Time of application--Postemergence when a majority of the foxtail is in the 2 to 3 leaf stage. Usually at this time the wheat will be in the 3 to 4 leaf stage.

Remarks--Do not apply propanil beyond the 5 leaf stage of HRS wheat or at rates of more than 1-1/2 pounds per acre or beyond the four leaf stage of durum wheat or rates higher than 1.13 pounds per acre, or severe injury to the crop may result. Do not tank mix with herbicides other than MCPA iso-octyl ester formulations. Do not apply Stampede to wheat that has been treated with soil applied systemic insecticides such as Furadan, Thimet or Disyston within the past year. Do not graze treated crop or cut for green chop feed. Do not apply if frost is expected within 24 hours or when temperatures are above 85°F, especially with drying winds.

Formulation--3 pounds per gallon liquid.

Pronamide (Kerb) - Rohm and Haas

Use--Annual and perennial grass control in pure stands of alfalfa, clover, birdsfoot trefoil, or crown vetch.

Rate of application--1 to 2 pounds per acre.

Time of application--Fall when soil temperatures are below 60° F. but before freeze-up.

Remarks--Do not graze or harvest alfalfa within 25 to 45 days depending on the rate of application or other crops for 120 days after application. Use only on established legume plantings or on new plantings after the legume has reached the trifoliolate leaf stage.

Formulation--50 percent wettable powder.

Propazine (Milogard) - Ciba-Geigy

Use--Control of annual grasses and broadleaved weeds in grain sorghum. Used in mixtures with propachlor on grain sorghum.

Rate of application--0.8 to 2 pounds per acre.

Time of application--Preemergence.

Remarks--Corn may be planted in rotation 12 months after treatment. Other crops should not be planted for 18 months following treatment. Do not use in sand or loamy sand soils.

Formulation--80 percent wettable powder.

Pyrazon (Pyramin) - BASF

Use--Control of most annual broadleafs in sugarbeets. Has been more effective on medium to coarse textured soils with less than 5 percent organic matter. May be applied preemergence with TCA.

Rate of application--3.8 to 7.6 pounds per acre.

Time of application--Preemergence or preplanting incorporated; postemergence when sugarbeets have two expanded true leaves and before weeds have more than 2 to 4 true leaves.

Remarks--A rain shortly after application is necessary for best results. Incorporation usually improves weed control. Do not use on sands or loamy sands as crop injury may occur; do not use preemergence on peat or muck soils.

Formulation--75.5 percent wettable powder or 4.2 pounds per gallon dispersible liquid.

Sethoxydim (Poast) - BASF

Use--Control of grassy weeds in soybeans.

Time of application--Early postemergence.

Remarks--Sethoxydim has given excellent control of most annual grassy weeds including volunteer corn, foxtails, wild proso millet and woolly cupgrass in soybeans. In addition, sethoxydim gives good suppression or control of several perennial grass weeds such as quackgrass and wirestem muhly. An oil concentrate is used with the spray mixture.

Formulation--1.53 pounds per gallon liquid.

Simazine (Princep) - Ciba-Geigy

Use--Control of grasses and broadleaved weeds in alfalfa, birdsfoot trefoil for seed, and corn.

Rate of application--0.8 to 1.6 pounds per acre on alfalfa and birdsfoot trefoil; 2 to 4 pounds per acre on corn.

Time of application--On established alfalfa, after last cutting in the fall and before the ground is frozen. Preplanting or preemergence on corn. Fall or spring on well established, dormant birdsfoot trefoil.

Remarks--Residues in the soil may injure susceptible crops planted the following year.

Formulation--80 percent wettable powder, 4 pounds per gallon liquid and 90 percent water dispersible granules.

TCA - Hopkins

Use--Control of annual grasses except wild oat in sugarbeets.

Rate of application--5 to 7 pounds per acre.

Time of application--Preemergence.

Formulation--4.76 pounds per gallon liquid.

Terbacil (Sinbar) - DuPont

Use-- Control of several annual broadleaf and grass weeds in alfalfa that has been established for one or more years. Treatment will not control established perennial weeds.

Rate of application--0.4 to 1.2 pounds per acre depending upon weed species to be controlled and on soil type and organic matter percentage. Use lower rate on coarse-textured soils with less than 2 percent organic matter.

Time of application--In the fall after alfalfa plants become dormant or in the spring before new growth starts.

Remarks--Do not use on seedling alfalfa or on alfalfa-grass mixtures or other mixed stands. Do not apply on established stands after new growth starts in the spring. Do not replant treated areas to any crop within two years after last application as injury to subsequent crops may result. There is potential for alfalfa injury, especially on sandy soils or soils low in organic matter.

Formulation--80 percent wettable powder.

Triallate (Far-go, Avadex-BW) - Monsanto

Use--Control of wild oat in spring and durum wheat and barley, peas and lentils.

Rate of application--1 to 1-1/4 pounds per acre on wheat; 1-1/4 to 1-1/2 pounds per acre on barley. Lower rates are for liquid formulation and higher rates are for granular formulation.

Time of application--Postseeding (preemergence) for wheat; preplanting or postseeding for barley (postseeding preferred). Fall application prior to barley or spring wheat is a possibility.

Remarks--Must be incorporated by two harrowings at right angles for postseeding applications. Incorporate preplanting applications as described previously for diallate. In postseeding applications, seed crop to a depth of 2 to 3 inches. Do not apply to a field in a ridged condition. Do not plant domestic oats where triallate was used the previous year. May be tank-mixed with trifluralin for spring postseeding application for wheat and barley. This chemical irritates skin and eyes; use caution when handling.

Formulation--4 pounds per gallon liquid; 10 percent granules.

Trifluralin (Treflan)

Use--Annual grass, pigweed and common lambsquarters control in soybeans, dry edible beans including adzuki beans, sunflowers, mustard, sugarbeets, and spring wheat. Used in mixtures with chloramben, metribuzin, chlorpropham or vernolate on soybeans; with chloramben and EPTC on dry beans; and with trialate on spring wheat.

Rate of application--1/2 to 1 pound per acre, depending on soil type. Use lower rates on coarse-textured soils and higher rates on finer-textured soils. On spring wheat, the rates are 1/2 to 3/4 pound per acre.

Time of application--Preplanting on soybeans, dry edible beans, mustard and sunflowers; postemergence on 2 to 6 inch sugarbeets after blocking or thinning and before new weeds come up. On spring wheat, apply immediately after planting, or the previous fall just before freezeup.
Remarks--Must be incorporated into the soil soon after application. Proper incorporation of preplanting applications can be accomplished by disking field twice, once in each direction, immediately after applying chemical. This chemical sometimes causes slight soybean stand reduction and early soybean injury. To reduce spring wheat injury potential, plant wheat 2 to 3 inches deep, apply the chemical and incorporate shallowly with a harrow operated in two different directions. Can be applied with fluid or dry bulk fertilizer.

Formulation--4 pounds per gallon liquid; 5 percent granular.

Vernolate (Vernam)

Use--Controls annual grasses and some broadleafs in soybeans. Cleared for use in mixtures with trifluralin, fluchloralin, and chloramben in soybeans. Cleared for sequential (overlay) treatments with chlorpropham, linuron, bentazon, and naptalam + dinoseb.

Rate of application--2 to 3 pounds per acre.

Time of application--Preplant incorporated; incorporate immediately.

Remarks--Vernolate must be incorporated immediately after application to prevent loss by violatilization. Incorporation should be done by disking twice or by using a power rotary tiller. Early soybean injury has sometimes occurred. Can be applied with fluid or dry bulk fertilizer.

HERBICIDE NAMES

This is an alphabetical list of trade names of herbicides commonly used on cropland in Minnesota. The active ingredient(s) in these products is given across from the chemical's common name.

Trade Name	Common Name/Active Ingredient
AAtrex	atrazine
Alanap	naptalam (NPA)
Amdon 10K	picloram
Amdon 101	picloram and 2,4-D
Amiben	chloramben
Asulox	asulam
Avadex	diallate
Avadex-BW	triallate
Avenge	difenzoquat
Balan	benefin
Banvel	dicamba
Banvel II	dicamba
Basagran	bentazon
Basalin	fluchloralin
Betamix	desmedipham + phenmedipham
Betanex	desmedipham
Bicep	metolachlor + atrazine
Bladex	cyanazine
Blazer	acifluorfen
Brominal	bromoxynil
Brominal Plus	bromoxynil and MCPA
Bronate	bromoxynil and MCPA
Buctril	bromoxynil
Butoxone	2,4-DB
Butyrac 200	2,4-DB
Carbyne	barban
Dacthal	DCPA
Dow General	dinoseb
Dowpon M	dalapon
Dowpon C	dalapon and TCA
Dual	metolachlor
Dyanap	naptalam and dinoseb
Endothal	endothall
Eptam	EPTC
Eradicane	EPTC plus crop protectant
Eradicane Extra	EPTC plus crop protectant plus extender
Evik	ametryne
Far-go	triallate
Furloe	chlorpropham
Fusilade	fluazifop

Trade Name (continued)	Common Name/Active Ingredient
Glean	chlorsulfuron
Goal	oxyfluorfen
Herbicide 273	endothall
Hoelon	diclofop
Kerb	pronamide
Kleen-Krop	naptalam and dinoseb
Lasso	alachlor
Lasso II	alachlor 15-percent granules
Lexone	metribuzin
Lorox	linuron
Milocep	propazine and metolachlor
Milogard	propazine
Modown	bifenox
MonDak	dicamba and MCPA
Nortron	ethofumesate
Paraquat	paraquat
Poast	sethoxydim (BAS-9052)
Premerge	dinoseb (DNBP)
Princep	simazine
Prowl	pendimethalin
Pyramin	pyrazon
Pyramin Plus	pyrazon and dalapon
Ramrod	propachlor
Ro-Neet	cycloate
Roundup	glyphosate
Sencor	metribuzin
Sinbar	terbacil
Stampede	propanil
Sutan +	butylate plus crop protectant
Sutazine	butylate plus crop protectant plus atrazine
TCA	TCA
Tordon	picloram
Tordon 212,101	picloram and 2,4-D
Treflan	trifluralin
Vernam	vernolate
Weedmaster	dicamba and 2,4-D

Omission of other trade names of similar herbicides is unintentional. The inclusion of a trade name does not imply endorsement and exclusion does not imply nonapproval.

SUGGESTIONS FOR CHEMICAL CONTROL OF WEEDS IN FIELD CROPS

Table 1. Suggestions for chemical control of weeds in field crops. Application rates are on a broadcast basis and refer to acid equivalent or active ingredient rather than amount of commercial product. Avoid repeated and prolonged contact with all herbicides, especially direct contact with the skin and eyes. Check label restrictions for use of crops for food or feed.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Corn	alachlor (Lasso) (Lasso II)	2 to 4 2.4 to 3.9	Preemergence or preplanting	Incorporate for nutsedge. May shallow incorporate for annual weeds.	None
	metolachlor (Dual)	1.5 to 3	Preplanting or preemergence	Incorporate for nutsedge. May shallow incorporate for annual weeds.	None
	atrazine	1 to 3	Preplanting, preemergence or early postemergence	Atrazine may injure crops the following year	Do not graze or feed forage for 21 days after treatment
	EPTC with protectant (Eradicane) or EPTC + protectant + extender (Eradicane Extra)	3 to 6	Preplanting incorporation	Do not use on corn seed stock.	None
	butylate (Sutan +)	4 to 6	Preplanting incorporation	Do not use on corn seed stock (Breeders, Foundation, Increase)	None
	propachlor (Ramrod, Bexton)	4 to 6	Preemergence		None
	cyanazine (Bladex)	2 to 4 2	Preplanting Preemergence Early Postemergence (80 W only).	Do not use on sandy soils. Use oil or surfactant postemergence under arid conditions only. (80 W only).	None
	atrazine and alachlor	1 to 2+ 1½ to 2½	Preplanting or preemergence		Do not graze or feed forage for 21 days after treatment.
	atrazine and metolachlor (Bicep or tank mix)	1 to 3+ 1¼ to 3	Preplanting or preemergence		
	cyanazine and alachlor	1 to 2.2+ 2 to 2½	Preplanting or preemergence	Do not use on sandy soils.	None
	cyanazine and metolachlor	0.8 to 2.5+ 1.25 to 2.5	Preplanting or preemergence	Do not use on sand or on loamy sand with less than 1% organic matter.	None
	cyanazine and propachlor	1 to 1.8 + 2.5 to 6	Preemergence	Do not use on sands with less than 2% organic matter.	None
	dicamba (Banvel) + alachlor	½ + 2 to 2½	Preemergence	Use only on medium or fine textured soils with more than 3% organic matter	Do not graze or feed silage prior to milk stage.
	dicamba and metolachlor	½ + 2 to 2½	Preemergence	Use only on medium or fine textured soils with more than 2.5% organic matter	Do not graze or feed silage prior to milk stage.
	atrazine and butylate (Sutazine or tank mix)	1 to 1½ + 3 to 4	Preplanting incorporation	Do not use on corn seedstock (Breeders, Foundation, Increase)	Do not graze or feed forage for 21 days after treatment.
	cyanazine and butylate	1 to 2 + 3 to 4	Preplanting incorporation		None
	atrazine and EPTC (Eradicane, Eradicane Extra)	1 to 1½ + 3 to 4	Preplanting incorporation	Do not use on corn seedstock.	None
	cyanazine and EPTC (Eradicane)	1½ to 2 + 3 to 4	Preplanting incorporation	Do not use on corn seedstock.	None
	atrazine and propachlor	1 to 1½ + 2 to 3¾	Preemergence		None

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Corn	linuron (Lorox) and alachlor	½ to 1½ + 1 to 3	Preemergence	Do not use on sandy soils.	Do not graze or harvest immature corn for feed within 12 weeks after treatment.
	linuron and propachlor	1 to 1½ + 2 to 3	Preemergence	Do not use on sandy soils.	None
	pendimethalin (Prowl) and atrazine	.75 to 1.5 + 1 to 1.5	Early postemergence (spike to 2-leaf stage corn)	Apply before weeds are 1 inch tall	None
	pendimethalin and cyanazine (80 W)	.75 to 1.5 + 1 to 2	Early postemergence (spike to 2-leaf stage corn)	Apply before weeds are 1 inch tall	None
	2,4-D amine	¼ to ½	Corn 4 inches to tasseling	Broadleafs only. Corn most susceptible during rapid growth. Use drop nozzles after corn is 8 inches tall.	Do not forage or feed fodder for 7 days following 2,4-D application.
	2,4-D ester	⅛ to ⅓			
	2,4-D amine	½ to 1	Corn over 3 feet	Spray base of stalks only.	
	2,4-D ester	⅓ to ⅔			
	dicamba (Banvel)	⅛ to ¼	Postemergence before corn is 2 feet tall and not within 15 days of tasseling.	See Precautions on page 6 to reduce risk of serious drift problems.	Do not graze or harvest for feed before milk stage.
	dicamba + 2,4-D amine	⅛ + ¼			
	bentazon (Basagran)	¾ to 1	Weeds 2 to 6 inches	Early applications most effective	None
	bentazon + atrazine (Laddock) + oil concentrate	½ to ¾ + ½ to ¾ + 1 qt/A	Postemergence before weeds 2 to 4 inches and corn 1 to 5 leaves.	Control broadleafs only	Do not graze treated area or feed treated to livestock 21 days following application.
Alfalfa, sweetclover, and birdsfoot trefoil in flax	MCPA amine	⅛ to ¼	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.	None
Legume establishment without a companion crop	benefin (Balan)	1⅛ to 1½	Preplanting incorporation	Alfalfa only	None
	EPTC (Eptam)	2 to 3			None
	profluralin (Tolban)	½ to 1			None
	2,4-DB amine	½ to 1½	1 to 4 trifoliolates on legumes	Sweetclover injured.	Do not graze within 60 days or cut hay within 30 days after application.
	2,4-DB ester	½ to 1			
Established alfalfa	2,4-DB amine	½ to 1½	When annual weeds are 1 to 3 inches tall (2 to 5 leaves)	May injure alfalfa	Do not graze within 60 days or cut hay within 30 days after application.
	2,4-DB ester	½ to 1			
	simazine (Princep)	0.8 to 1.6	Fall	May injure alfalfa.	Do not graze for 30 days or cut hay for 60 days after treatment.
	metribuzin (Lexone, Sencor)	⅜ to 1	Fall or spring when alfalfa is dormant.	May injure alfalfa.	Do not graze or harvest within 28 days of application.
	terbacil (Sinbar)	¼ to ¾		May injure alfalfa.	Do not plant other crops within 2 years after application.
	pronamide (Kerb)	1 to 2	Fall	May injure alfalfa	Do not graze or harvest alfalfa within 25 to 45 days after application.
	hexazinone (Velpar)	0.45 to 1.35	Fall or spring when alfalfa is dormant	May injure alfalfa	Do not graze or feed treated forage within 30 days after application.

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Established grass pastures	2,4-D	½ to 2	Before bud stage, preferably when weeds are 2 to 6 inches tall and growing vigorously. When woody plants are fully leaved.	Rate depends on kinds of weeds. Use MCPA only at low rates, if legumes are present. Use 2, 4-D, dicamba, picloram, or mixture of these for woody plant control. Avoid drift, especially of dicamba or picloram to susceptible crops, particularly soybeans and sunflowers. Read label precautions before using picloram.	Do not graze dairy animals on treated areas within 7 to 14 days after application of 2,4-D See label. Do not cut 2,4-D treated grass for hay for 30 days. Do not graze dairy animals for 7 to 21 days after application of these rates of dicamba. See label. Do not graze or feed forage for two weeks after application of picloram
	MCPA	¼ to 2			
	dicamba (Banbel)	½ to 1			
	picloram (Tordon 22K & 2K)	½ to 2			
Dry edible beans	chloramben (Amiben)	3	Preemergence		None
	EPTC (Eptam)	3	Preplant incorporation	Incorporate immediately. Do not use on adzuki beans.	None
	trifluralin (Treflan)	½ to 1	Preplant incorporation		None
	fluchloralin (Basalin)	½ to 1	Preplant incorporation	Do not use on adzuki beans.	None
	alachlor (Lasso)	2½ to 3	Preplant incorporation	Do not use on adzuki beans.	None
	metolachlor (Dual)	1½ to 3	Preplant incorporation or Preemergence	Do not use on adzuki beans	None
	bentazon (Basagran)	¾ to 1	Postemergence	Beans in first trifoliolate, weeds less than 2 inches and 4 true leaves.	None
Sugarbeets	TCA	5 to 7	Preemergence	For grass weeds except wild oat.	Do not use treated tops for food or feed.
	pyrazon (Pyramin) + TCA	3.8 to 7.6 + 5 to 7	Preemergence or preplanting incorporation	Has been less effective on soils with more than 5% organic matter	None
	dalapon	2 to 3	Beets up to 6-leaf stage	For grass weeds except wild oat.	None
		2½ to 3½	Directed, beets 7-leaf stage to 14 inches		
	diallate (Avadex)	1½ to 2	Preplanting incorporation	For wild oat. Spring or fall application.	Do not graze unharvested crop
	barban (Carbyne)	⅔ to 1	Wild oat in two-leaf stage	For wild oat.	Do not allow livestock to graze treated fields until after crop is harvested.
	desmedipham + phenmedipham (Betamix)	0.365 to 0.6 + 0.365 to 0.6	Early postemergence		Do not apply within 90 days of harvest.
	desmedipham (Betanex)	1 to 1¼	Early postemergence		
	endothall (Herbicide 273)	¾ to 1½	Early postemergence	For wild buckwheat and annual smartweed.	None
	EPTC (Eptam)	2 to 3—spring 4 to 4.5—fall	Preplanting incorporation	For grass and some broad-leaved weeds.	None
	ethofumesate (Nortron)	2 to 3¾	Preplanting incorporation		None
	cycloate (Ro-neet)	3 to 4	Preplanting incorporation	For grass weeds and some annual broadleafs. Similar performance to EPTC but less injury.	None
	diethatyl (Antor)	4 to 6	Preplanting incorporation	For pigweed and some annual grasses	None

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Sugarbeets	ethofumesate (Nortron) + desmedipham (Betanex)	1.12 to 1.5 + 0.73 to 1.0	Postemergence, beets with 6 leaves or larger	Improved weed control and more sugarbeet injury than from desmedipham or desmedipham + phenmedipham.	Do not apply these combinations to crops previously treated with ethofumesate.
	ethofumesate (Nortron) + desmedipham + phenmedipham	1.12 to 1.5 + 0.365 to 0.5 + 0.365 to 0.5			
Soybeans	acifluorfen (Blazer)	⅜ to ½	Early postemergence (soybeans in first trifoliolate, weeds less than 2 inches tall and 4 true leaves)	Controls many annual broadleafs, including black nightshade	Do not graze or use soybean hay or forage.
	alachlor (Lasso)	2 to 4	Preplant incorporation or preemergence	Incorporate for nutsedge control	None
	chloramben (Amiben)	3	Preplant incorporation or preemergence	May shallow incorporate for annual weeds.	None
	chlorpropham (Furloe Chloro IPC)	2 to 3	Preplant incorporation or preemergence	For smartweed control	None
	diclofop (Hoelon)	¾ to 1¼	Early postemergence when soybeans are between the first and sixth trifoliolate leaf stage, before annual grasses exceed 4 leaves before volunteer corn exceeds 10 inches	Controls many annual grasses, any volunteer corn	Do not graze or use soybean hay or forage.
	linuron	½ to 2½	Preemergence	Increased soybean injury potential at high use rates. Use in combinations at lowered use rates. Do not use on soils with organic matter above 5 percent or below ½ percent	None
	metolachlor (Dual)	1½ to 3	Preplant incorporation or preemergence	Incorporate for nutsedge control	Do not graze or feed soybean hay or forage.
	metribuzin (Sencor Lexone)	¼ to ¾	Preplant incorporation or preemergence	Increased soybean injury potential at high use rates. Use in combinations at lowered use rates. See label for soil restrictions. Soybean injury may occur on alkaline soils, sandy soils or where atrazine residues are present.	None
	fluchloralin (Basalin)	½ to 1½	Preplant incorporation	Must be incorporated	Do not graze or feed forage
	pendimethalin (Prowl)	½ to 1½	Preplant incorporation	Incorporate	None
	trifluralin (Treflan)	½ to 1	Preplant incorporation	Must be incorporated	None
	vernolate (Vernam)	2 to 3	Preplant incorporation	Incorporate immediately	None
	bentazon (Basagran)	¾ to 1½	Early postemergence (soybeans in first trifoliolate, weeds less than 2 inches and 4 true leaves)	Controls most annual broadleafs, Canada thistle, nutsedge	None

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Spring wheat or barley	bromoxynil and MCPA esters	¼ + ¼	Two leaf to early boot	Use for smartweeds or wild buckwheat. Do not use on underseeded legumes.	Do not forage or graze for 30 days after treatment.
	bromoxynil (Brominal, Buctril)	¼ to ½	Two leaf to early boot		
	diclofop	¾ to 1¼ (wheat)	1 to 4 leaf stage of grass weeds (wheat)	For annual grass weeds including wild oat. Use high rate for larger weeds. May be tank-mixed with bromoxynil. Do not apply other herbicides within one week of diclofop application.	Do not graze treated areas or harvest forage from treated fields prior to grain harvest.
		¾ to 1 (barley)	1 to 3 leaf stage of grass weeds (barley)		
	picloram and 2,4-D amine	1/64 to 3/128 + ¼ to ⅜	4-leaf to early boot	May persist in the soil to harm most broadleaf crops. Use only where grass or grain crop will be planted the following year.	None
Spring wheat or oats	dicamba and MCPA amine	⅛ + ¼	Two- to five-leaf stage	Kills legumes. Use if weeds include smartweeds or wild buckwheat.	Do not graze treated areas or harvest for dairy feed prior to crop maturity.
Oats	2,4-D amine	¼ to ½	Sixth leaf to early boot	MCPA less injurious to crop.	Do not forage or graze for 2 weeks after treatment.
	MCPA amine	¼ to ⅔	Two leaf to early boot	Bromoxynil for smartweed and wild buckwheat.	None
	MCPA ester	⅛ to ½			None
	bromoxynil	¼ to ⅜			Do not forage or graze for 30 days after treatment.
Flax	MCPA	¼	Flax 2 to 6 inches	Mixture of MCPA amine with dalapon for broadleaved and grass weeds.	None
	dalapon	¾	Flax 2 to 6 inches		None
	EPTC (Eptam)	2 to 3	Preplanting incorporation	Fall application only	None
	bromoxynil	¼ to ½	Flax 2 to 8 inches	For smartweed, wild buckwheat in 2 to 4 leaf stage.	Do not graze for 30 days after treatment.
	trifluralin	½ to 1	Preplanting incorporation	Fall application only For annual grasses	None
Alfalfa and clover in small grains	Some formulations of 2,4-D amine or MCPA amine (See label)	⅛ to ¼	Not before clover is 2 inches tall	Injures legumes. Canopy of crop or weeds reduces injury. Do not use on sweetclover.	Do not graze dairy animals on treated areas within 7 days after application of 2,4-D.
Sunflowers	chloramben (Amiben)	2 to 3	Preemergence		Do not graze or feed forage.
	EPTC (Eptam)	2 to 3	Preplanting incorporation		None
	trifluralin (Treflan)	½ to 1	Preplanting incorporation		None
	fluchloralin (Basalin)	¾ to 1½	Preplanting incorporation		Do not feed treated forage to livestock.
	pendimethalin (Prowl)	½ to 1½	Preplanting incorporation		Do not feed treated forage to livestock.
	pendimethalin + chloramben	¾ to 1¼ + 2	Preplanting incorporation		Do not feed treated forage to livestock.
	trifluralin + EPTC	½ to 1 + 2	Preplanting incorporation		None
	EPTC + Chloramben	2 to 3 + 1 to 2	Preplanting incorporation		Do not graze or feed forage.

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Soybeans	2,4-DB amine	1/5	Postemergence directed	For cocklebur control	Do not harvest within 60 days after application
Winter wheat	2,4-D amine 2,4-D ester MCPA	1/4 to 3/4 1/4 to 1/2 1/4 to 3/4	Wheat fully tillered to boot stage.	For broadleafs	Do not graze or feed forage from 2,4-D treated fields within 2 weeks after treatment. None for MCPA
	dicamba + MCPA amine	1/8 + 1/4 to 3/8	After winter dormancy until wheat begins to joint.	For broadleafs	Do not graze dicamba treated fields or harvest for dairy feed prior to crop maturity.
	dicamba + 2,4-D amine	1/8 + 1/4 to 3/8			
	bromoxynil bromoxynil + MCPA ester	1/4 to 1/2 1/4 + 1/4	Wheat fully tillered to boot stage	For broadleafs	Do not forage or graze for 30 days after treatment with bromoxynil.
	diclofop	3/4 to 1 1/4 (wheat) 3/4 to 1 (barley)	1 to 4 leaf stage of grass weeds (wheat) 1 to 3 leaf stage of grass weeds (barley)	For annual grass weeds including wild oat. Use high rate for larger weeds. May be tank-mixed with bromoxynil. Do not apply other herbicides within one week of diclofop application.	Do not graze treated areas or harvest forage from treated fields prior to grain harvest.
	picloram and 2,4-D amine	1/64 to 3/128 + 1/4 to 3/8	4-leaf to early boot	May persist in the soil to harm most broadleaf crops. Use only where grass or grain crop will be planted the following year.	None
Rye	2,4-D amine 2,4-D ester MCPA amine or ester	1/4 to 3/4 1/4 to 1/2 1/4 to 3/4	Rye fully tillered to boot stage		Do not graze or feed forage from 2,4-D treated fields for 2 weeks after treatment. None for MCPA.
Spring wheat	propanil	1 1/2	3 to 5 leaf stage of wheat	For annual grasses and certain broadleafs. May cause temporary leaf injury or a slight delay in maturity. Do not use on fields previously treated or to be treated this year with organophosphorus or carbamate insecticides.	Do not graze treated crop or cut for green chop feed.
	propanil + MCPA iso-octyl ester	1 1/8 + 1/4	2 to 4 leaf stage or grass weeds		
Spring wheat or barley	2,4-D amine 2,4-D ester	1/4 to 2/3 1/8 to 1/2	Fifth leaf to early boot	Amine less injurious to crop. May injure legumes.	Do not forage or graze for 2 weeks after treatment.
	MCPA amine MCPA ester	1/4 to 2/3 1/8 to 1/2	Two leaf to early boot	May injure legumes.	None
	trifluralin (Treflan)	1/2 to 3/4	Postplanting incorporation in spring or preplanting incorporated in fall prior to spring seeding.	Improper application may result in crop injury. May be tank-mixed with triallate in spring, not in fall.	None
	Chlorsulfuron	1/96 to 1/32	Preemergence or Postemergence	For broadleafs and grasses. Follow label directions to avoid carry-over injury to sensitive crop.	

Table 2. Suggestions for chemical control of specific weeds on cropland. Follow label precautions carefully.

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Canada and sowthistle	2,4-D amine	½	Just before bud	Can spray in tolerant crops.	See crop
	2,4-D ester	1	Fall rosette	Plow or clip in fall and spray when 6 inches.	See crop
	dicamba (Banvel)	⅛ to ¼		See crop discussion. Drift may affect sensitive crops. Use for patch treatment of 2,4-D-resistant thistles.	See discussion sections on oats, wheat, corn, and pastures.
	glyphosate (Roundup)	1½	Bud stage or in fall before frost	May be used before planting or for spot treatment in barley, corn, oats, sorghum, soybeans, wheat (kills crop)	Do not feed or forage subsequently grown crop for 8 weeks after application.
	bentazon (Basagran)	¾ to 1 each time-two applications or 1 to 1½ one application	8- to 12-inch thistles Repeat 7 to 10 days later. 8- to 12-inch thistles	For soybeans or corn Split applications usually better than one.	See crop
Field bindweed	2,4-D ester	1	Late fall	Re-treat second year.	See crop
	2,4-D amine	½	Bud to bloom		See crop
	glyphosate (Roundup)	2¼ to 3¾	Full bloom to frost	May be used before planting or for spot treatment in barley, corn, oats, sorghum, soybeans, wheat (kills crops)	Do not feed or forage subsequently grown crop for 8 weeks after application.
Germander, field mint	atrazine + oil	2	Early postemergence	For corn	See crop
	EPTC (Eradicane)	4 to 6	Preplanting, incorporated	For corn	See crop
Jerusalem artichoke	2,4-D	⅜ to ½	6-inch artichoke. Repeat when regrowth reaches 6 to 8 inches.	Use during crop tolerant periods in corn, small grains, pastures.	See crop
Leafy spurge	2,4-D ester	2 to 3	Bud	After grain harvest or on grass pastures. Re-treat growth when 4 to 6 inches.	See crop
	2,4-D ester	½	Bud	In corn, wheat, or barley. Cultivate after harvest until freezeup.	See crop
Yellow nutsedge	metolachlor (Dual)	3	Preplanting, incorporated	For corn, soybeans	See crop
	alachlor (Lasso)	4		For corn, soybeans	See crop
		3		For dry beans	See crop
	butylate (Sutan +)	4 to 6		For corn	See crop
	EPTC (Eptam)	3		For dry beans, sugarbeets, sunflowers	See crop
	EPTC + protectant (Eradicane)	4 to 6		For corn	See crop
	vernolate (Vernam)	3		For soybeans	See crop
	atrazine + oil	2	Postemergence after a preplanting treatment when nutsedge is less than 3 inches tall.	For corn	See crop

Table 2. (continued) Suggestions for chemical control of specific weeds on cropland. Follow label precautions carefully.

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	EPA registration Remarks	EPA registration limitations on crop use
	bentazon (Basagran)	¾ to 1 each time-two applications or 1 one application	6- to 8-inch nutsedge Repeat 7 to 10 days later. 6- to 8-inch nutsedge	For soybeans or corn Split applications usually better than one.	See crop
Quackgrass	dalapon (Dowpon)	11	Fall	Foliage application, plow 1 or 2 weeks later. May plant corn, dry beans, some varieties of potatoes, sugarbeets next spring.	Do not graze treated areas in year treated.
	EPTC (Eradicane)	6	Preplanting incorporated	For more consistent control, apply glyphosate or atrazine in the fall followed by EPTC in the Spring.	
Quackgrass Wirestem muhly (muhlenbergia)	atrazine	2 to 4	Spring or fall Split application in fall and spring preferred.	Use low rate on sandy soils. Only corn can be grown the year after treatment.	See corn.
	glyphosate (Roundup)	1½	Fall or Spring before plowing or for spot treatment in crop (kills crop)	Quackgrass should be at least 8 inches tall (3 to 4 leaf stage) and actively growing.	Do not feed or graze treated crops within 8 weeks after application.
		¾	Fall		
Wild oat	barban (Carbyne)	¼ to ⅜	When wild oat is in two-leaf stage. Before 4-leaf stage of spring small grains, before 12-leaf stage of flax, within 30 days after emergence of sugarbeet, sunflower, mustard, soybean	Rate for wheat, barley, flax. Two applications may be made.	Do not allow livestock to graze treated fields until after crop is harvested. Do not feed soybean forage or flax straw from treated fields.
	barban (Carbyne)	⅜		Rate for semidwarf wheat varieties, sunflower, mustard, soybeans	
	barban (Carbyne)	¾ to 1		Rate for sugarbeets.	
	diallate (Avadex)	1½ to 2 (liquid)	Preplanting or preemergence, fall or spring	Rate for flax and sugarbeets; must be incorporated into soil.	None
	diallate (Avadex)	1½		Rate for corn	
	diallate (Avadex)	1½ to 2 (granules)	Fall or spring, preplanting incorporated.	For sugarbeets.	None.
	triallate (Far-go)	1 to 1¼ (wheat) 1¼ to 1½ (barley)	Preplanting or preemergence fall or spring.	Must be incorporated into soil. Use the higher rate for granules, lower rate for liquids.	Do not graze livestock on treated areas. May be tank-mixed with trifluralin or wheat or barley.
	difenzoquat (Avenge)	⅝ to 1	When wild oat has 3 to 5 leaves.	For barley, winter wheat and the spring and durum wheat varieties listed on the label.	Do not graze treated fields or cut for silage. Grain and straw can be fed.
	diclofop (Hoelon)	¾ to 1¼	When grass weeds have 1 to 4 leaves. Use higher rates for larger weeds.	May be tank-mixed with bromoxynil	Do not graze treated areas or cut for forage prior to grain harvest.

Effectiveness of herbicides on weeds in corn[1]

	Preplanting						Preemergence								Postemergence							
	Alachlor (Lasso)	Metolachlor (Dual)	Butylate (Sutan+)	EPTC (Eradicane)	Cyanazine (Bladex) + Atrazine (AAtrex, others)		Alachlor (Lasso)	Atrazine (AAtrex, others)	Dicamba (Banvel)	Metolachlor (Dual)	Pendimethalin (Prowl)	Propachlor (Ramrod, Bexton)	Linuron (Lorox)	Cyanazine (Bladex)	2, 4-D	Dicamba (Banvel)	Atrazine and oil	Cyanazine (Bladex)	Bentazon (Basagran)	Bentazon + atrazine (Laddok)	Pendimethalin (Prowl) + atrazine	Pendimethalin (Prowl + cyanazine (Bladex 80W)
Corn tolerance–	G	G	G	G	F	G	G	G	F	G	F	G	F	F	F	G	G	F	G	G	F/G	F
Grasses–																						
Giant & robust foxtail	G	G	G	G	F	F	G	F	P	G	F	G	F	F	N	N	F	F	N	F	G	G
Green foxtail	G	G	G	G	G	G	G	G	P	G	F	G	F	G	N	N	G	G	N	F	G	G
Yellow foxtail	G	G	G	G	G	G	G	G	P	G	F	G	F	G	N	N	G	G	N	F	G	G
Barnyardgrass	G	G	G	G	F	F	G	F	P	G	F	F	F	F	N	N	F	F	N	F	G	G
Crabgrass	G	G	G	G	F	P	G	P	P	G	F	G	G	F	N	N	P	F	N	P	F/G	G
Panicum	G	G	G	G	F	P	G	P	P	G	F	F	G	F	N	N	P	F	N	P	F/G	G
Nutsedge	G	G	G	G	P	P	F	P	N	F	N	F	P	P	N	N	F	P	G	G	P	P
Quackgrass	N	N	N	F	P	G	N	G	N	N	N	N	N	P	N	N	G	P	N	P	P	P
Woolly cupgrass	G	G	F	G	P	P	G	P	P	G	F	F	P	P	N	N	F	F	N	P	F	F/G
Wild proso millet	F	F	F	F/G	P/F	P	F	P	P	F	F	F	P	P/F	N	N	P	F	N	P	F	F/G
Wild oat	P	P	F	F	F	G	P	G	N	P	F	P	G	F	N	N	G	F	N	G	G	G
Broadleafs–																						
Buffalo bur	P	P	F	G	P	P	P	P	P	P	P	P	P	P	P	P	G	F	P	G	G	F
Cocklebur	N	N	P	P	F	F	N	F	F	N	P	P	P	F	G	G	G	F	G	G	G	F
Kochia	P	P	P	F	G	G	P	G	F	P	F	P	F	G	F	G	G	G	–	G	G	G
Lambsquarters	F/P	F/P	P	F/G	G	G	F/P	G	G	F/P	F	P	G	G	G	G	G	G	F	G	G	G
Mustard	P	P	P	P	G	G	P	G	G	P	P	P	G	G	G	F	G	G	G	G	G	G
Pigweed	G	G	F	F	F	G	G	G	G	G	F	F	G	F	G	G	G	F	P	G	G	F
Ragweed	P	P	P	F	G	G	P	G	G	P	P	P	G	G	G	G	G	G	G	G	G	G
Smartweed	P	P	P	P	G	G	P	G	G	P	F	P	F	G	P	G	G	G	G	G	G	G
Velvetleaf	P	P	F	F	F	F	P	F	F	P	F	P	F	F	G	G	F	F/G	G	G	G	G
Wild sunflower	P	P	P	P	F	F	P	F	F	P	P	P	P	F	F	G	G	F/G	G	G	G	G
Canada thistle	N	N	N	N	P	P	N	P	N	N	N	N	N	P	F	G	F	P	F	F	P	P
Jerusalem artichoke	N	N	N	N	P	P	N	P	P	N	N	N	P	P	G	G	P	P	P	P	P	P
American germander	N	N	P	F	P	P	N	P	P	N	N	N	P	P	P	P	G	F	P	F	F	F

[1]G = Good, F = Fair, P = Poor, N = None

Effectiveness of herbicides on major weeds in soybeans

	Preplant incorporated								Preemergence							Postemergence								
	Alachlor (Lasso)	Chloramben (Amiben)	Fluchloralin (Basalin)	Metolachlor (Dual)	Metribuzin (Sencor or Lexone)	Pendimethalin (Prowl)	Trifluralin (Treflan)	Vernolate (Vernam)	Alachlor (Lasso)	Chloramben (Amiben)	Chlorpropham (Furloe Chloro IPC)	Naptalam + Dinoseb (Dyanap)	Linuron (Lorox)	Metolachlor (Dual)	Metribuzin (Sencor or Lexone)	Acifluorfen (Blazer)	Bentazon (Basagran)	2,4-DB (Butoxone or Butyrac 200)	Diclofop (Hoelon)	Dinoseb (Premerge)	Naptalam (Alanap L)	Naptalam + Dinoseb (Dyanap)	Fluazifop (Fusilade)	Sethoxydim (Poast)
Soybean tolerance	G	G	F/G	G	F	F/G	F/G	F	G	G	G	P	F	G	F	—	F	G	P	G	P	G	G	G
Grasses																								
Giant foxtail	G	G	G	G	F	G	G	G	G	G	P	P	F	G	F	P	N	N	G	P	P	P	G	G
Green foxtail	G	G	G	G	F	G	G	G	G	G	P	P	F	G	F	P	N	N	G	P	P	P	G	G
Yellow foxtail	G	G	G	G	F	G	G	G	G	G	P	P	F	G	F	P	N	N	F	P	P	P	G	G
Barnyardgrass	G	G	G	G	F	G	G	G	G	G	P	P	F	G	F	P	N	N	G	P	P	P	G	G
Wild proso millet	F	F	F	F	P	F	F	F	F	F	P	P	P	F	P	P	N	N	P	P	P	P	G	G
Nutsedge	G	P	N	G	P	N	N	G	F	P	N	P	P	F	P	P	F	N	P	P	P	P	N	N
Woolly cup grass	G	G	G	G	P	G	G	F/G	G	G	P	P	P	G	P	P	N	N	P	P	P	P	G	G
Quackgrass	N	N	P	N	P	P	P	F	N	N	N	P	P	N	P	N	N	N	N	P	N	P	F	F
Broadleafs																								
Eastern Black nightshade	F	F	P	F	P	P	P	P	G	G	P	—	P	G	P	G	F	—	N	G	—	—	N	N
Hairy nightshade	F	P	F	F	P	P	P	P	G	G	P	—	—	G	P	P	G	—	N	—	—	—	N	N
Cocklebur	P	P	N	N	F	N	N	P	N	P	P	F	P	N	F	F	G	F	N	F	P	F	N	N
Kochia	P	G	G	P	G	G	G	—	P	G	P	F	F	P	G	—	—	—	N	—	F	F	N	N
Lambsquarters	F/P	G	G	F/P	G	G	G	G	F/P	G	P	F	G	F/P	G	P	F	P	N	P	—	F	N	N
Mustard	P	F	P	P	G	N	N	F	P	F	F	G	G	P	G	G	G	P	N	G	—	G	N	N
Pigweed	G	G	G	G	G	G	G	G	G	G	P	F	G	G	G	G	P	P	N	P	—	F	N	N
Common ragweed	P	G	N	P	G	N	N	P	P	G	P	—	G	P	G	G	G	P	N	F	—	—	N	N
Giant ragweed	P	F	N	P	F	N	N	P	P	F	P	—	F	P	F	G	F	F	N	—	—	—	N	N
Smartweed	P	G	P	P	G	F	P	P	P	G	G	F	F	P	G	G	G	P	N	G	—	F	N	N
Velvetleaf	P	F	N	P	F	F	N	F	P	F	P	—	F	P	F	P	G	P	N	P	—	—	N	N
Venice mallow	P	G	P	P	G	P	P	G	P	G	P	—	G	P	G	—	G	P	N	—	—	—	N	N
Wild sunflower	P	P	N	P	F	N	N	P	P	P	P	—	P	P	F	F/G	G	P	N	F	—	—	N	N
Canada Thistle	N	N	N	N	P	N	N	N	N	N	N	P	P	N	P	P	G	P	N	P	P	P	N	N

G = good; F = fair; P = poor; N = no control; — = insufficient information.

Effectiveness of herbicides on major weeds in sugar beets

	Preplanting				Preemergence or Preplanting			Postemergence				
	Diethatyl (Antor)	Cycloate (Ro-neet)	Diallate (Avadex)	EPTC (Eptam)	Ethofumesate (Nortron)	Pyrazon (Pyramin)	TCA	Barban (Carbyne)	Dalapon (Dowpon, Basfapon)	Endothall (Herbicide 273)	Desmedipham (Betanex)	Desmedipham + Phenmedipham (Betamix)
Sugar beet tolerance	G	G	G	F	G	G	G	G	F	F	F	F
Grasses												
Giant foxtail	F/G	G	P	G	G	P	G	P	G	P	P	F
Green foxtail	F/G	G	P	G	G	P	G	P	G	P	P	F
Yellow foxtail	F/G	G	P	G	P	P	G	P	G	P	P	F
Barnyardgrass	P/F	G	P	G	P	P	G	P	G	P	P	P
Wild oat	P/F	F	G	F	F	P	P	G	F	P	P	P
Broadleafs												
Common ragweed	P	F	P	F	P	G	P	P	P	F	G	G
Lambsquarters	P	F	P	F	F	G	P	P	P	P	G	G
Marshelder	P	P	P	P	P	P	P	P	P	G	P	P
Pigweed	G	F	P	F	G	G	P	P	P	F	G	P
Smartweed	P	P	P	P	G	G	F	P	P	G	F	F
Wild buckwheat	P	P	P	P	G	G	P	P	P	G	F	G
Wild mustard	P	P	P	P	P	G	P	P	P	P	G	G
Volunteer sunflower	P	P	P	P	P	P	P	P	P	F	P	P
Kochia	P	P	P	F	G	F	P	P	P	P	P	F
Common cocklebur	P	P	P	P	P	F	P	P	P	P	F	G

G — Good
F — Fair
P — Poor

Effectiveness of herbicides on major weeds in small grains and flax 1/

	Small grains													Flax						
	trifluralin (Treflan)	triallate (Far-go)	diallate (Avadex)	2,4-D amine or ester	MCPA amine or ester	bromoxynil (Brominal/ Buctril)	dicamba (Banvel)	picloram (Tordon 22K)	barban (Carbyne)	difenzoquat (Avenge)	diclofop (Hoelon)	propanil (Stampede)	chloroxuron (Glean)	MCPA amine/ester	bromoxynil	dalapon (Dowpon)	barban (Carbyne)	diallate (Avadex)	EPTC (Eptam)	trifluralin (Treflan)
Grasses																				
Green foxtail	G	N	N	N	N	N	N	N	N	N	G	G	G	N	N	G	N	N	G	G
Yellow foxtail	G	N	N	N	N	N	N	N	N	N	F	G	G	N	N	G	N	N	G	G
Barnyardgrass	G	N	N	N	N	N	N	N	N	N	G	G	G	N	N	G	N	N	G	G
Wild oat	P	G	G	N	N	N	N	N	G	G	G	P	P	N	N	F	G	G	F	P
Broadleafs																				
Wild mustard	N	N	N	G	G	F	P	P	N	N	N	F	G	G	F	N	N	N	P	N
Wild buckwheat	P	N	N	F	F	G	G	G	N	N	N	G	G	F	G	N	N	N	P	P
Lambsquarters	G	N	N	G	G	G	G	F	N	N	N	G	G	G	G	N	N	N	F	G
Pigweed	G	N	N	G	G	G	G	F	N	N	N	G	G	G	G	N	N	N	F	G
Smartweed (annuals)	P	N	N	F	F	G	G	P	N	N	N	P	G	F	G	N	N	N	P	P
Common ragweed	N	N	N	G	G	G	G	F	N	N	N	P	G	G	G	N	N	N	F	N
Giant ragweed	N	N	N	G	G	G	G	F	N	N	N	P	G	G	G	N	N	N	P	N
Kochia	P	N	N	G	G	G	G	F	N	N	N	F	G	G	G	N	N	N	P	P
Marshelder	P	N	N	G	G	G	G	F	N	N	N	P	—	G	G	N	N	N	P	P
Canada thistle	N	N	N	F	F	N	G	P	N	N	N	N	G	F	N	N	N	N	N	N
Perennial sowthistle	N	N	N	F	F	N	G	P	N	N	N	N	F	F	N	N	N	N	N	N

G = good; F = fair; P = poor; N = no control; — insufficient information

1/ Effectiveness ratings apply if herbicide is used according to label recommendations as to rate, time of application, etc. and if favorable temperature and moisture conditions prevail.